Elektro-Automatik

Operating Manual

EL 3000 B

Electronic DC Load

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1. General

1.1 About this document

1.1.1 Retention and use

This document is to be kept in the vicinity of the equipment for future reference and explanation of the operation of the device. This document is to be delivered and kept with the equipment in case of change of location and/or user.

1.1.2 Copyright

1.1.3 Validity

This manual is valid for the following equipment, including derived variants.

Model	Article nr.
EL 3080-60 B	35 320 205
EL 3200-25 B	35 320 206
EL 3500-10 B	35 320 207

1.1.4 Symbols and warnings

Warning and safety notices as well as general notices in this document are shown in a box with a symbol as follows:

	**Symbol for a life threatening danger**
	Symbol for general safety notices (instructions and damage protection bans)
	*Symbol for general notices*

1.2 Warranty

EA Elektro-Automatik guarantees the functional competence of the device within the stated performance parameters. The warranty period begins with the delivery of free from defects equipment.

Terms of guarantee are included in the general terms and conditions of EA Elektro-Automatik.

1.3 Limit of liability

All statements and instructions in this manual are based on current norms and regulations, up-to-date technology and our long term knowledge and experience. EA Elektro-Automatik accepts no liability for losses due to:

- Usage for purposes other than defined
- Use by untrained personnel
- Rebuilding by the customer
- Technical changes
- Use of non authorized spare parts

The actual delivered device(s) may differ from the explanations and diagrams given here due to latest technical changes or due to customized models with the inclusion of additionally ordered options.

1.4 Disposal of equipment

A piece of equipment which is intended for disposal must, according to European laws and regulations (ElektroG, WEEE) be returned to EA Elektro-Automatik for scrapping, unless the person operating the piece of equipment or another, delegated person is conducting the disposal. Our equipment falls under these regulations and is accordingly marked with the following symbol:

1.5 Product key

Decoding of the product description on the label, using an example:

EL 3080 - 60 B

B	Construction/Version: **B** = Second generation
60	Maximum current of the device in Ampere
080	Maximum voltage of the device in Volt
3	Series : **3** = Series 3000
EL	Type identification: **EL** = Electronic Load, always programmable

Special models are always derived from standard models and can vary in input voltage and current from those given.

1.6 Intended usage

The equipment is intended to be used, if a power supply or battery charger, only as a variable voltage and current source, or, if an electronic load, only as a variable current sink.

Typical application for a power supply is DC supply to any relevant user, for a battery charger the charging of various battery types and for electronic loads the replacement of Ohm resistance by an adjustable DC current sink in order to load relevant voltage and current sources of any type.

- Claims of any sort due to damage caused by non-intended usage will not be accepted.
- All damage caused by non-intended usage is solely the responsibility of the operator.

1.7 Safety

1.7.1 Safety notices

Mortal danger - Hazardous voltage

- **Electrical equipment operation means that some parts will be under dangerous voltage. Therefore all parts under voltage must be covered!**
- **All work on connections must be carried out under zero voltage (input not connected to voltage sources) and may only be performed by qualified and informed persons. Improper actions can cause fatal injury as well as serious material damage.**
- **Never touch cables or connectors directly after unplugging from mains supply as the danger of electric shock remains.**
- **Never touch a blank contact on the DC input right after usage of the device, because between DC- and DC+ there is potential against ground (PE) which discharges more or less slowly or not at all!**

- The equipment must only be used as intended
- The equipment is only approved for use within the connection limits stated on the product label.
- Do not insert any object, particularly metallic, through the ventilator slots
- Avoid any use of liquids near the equipment. Protect the device from wet, damp and condensation.
- For power supplies and battery chargers: do not connect loads, particularly such with low resistance, to devices under power; sparking may occur which can cause burns as well as damage to the equipment and to the load.
- For electronic loads: do not connect power sources to equipment under power, sparking may occur which can cause burns as well as damage to the equipment and to the source.
- ESD regulations must be applied when plugging interface cards or modules into the relative slot
- Interface cards or modules may only be attached or removed after the device is switched off. It isn't necessary to open the device.
- Do not connect external power sources with reversed polarity to DC inputs or outputs! The equipment will be damaged.
- For power supply devices: avoid where possible connecting external power sources to the DC output, and never those that can generate a higher voltage than the nominal voltage of the device.
- For electronic loads: do not connect a power source to the DC input which can generate a voltage more than 120% of the nominal input voltage of the load. The equipment isn't protected against over voltage and may be irreparably damaged.
- Always configure the various protecting features against overcurrent, overpower etc. for sensitive sources to what the currently used application requires

1.7.2 Responsibility of the user

The equipment is in industrial operation. Therefore the operators are governed by the legal safety regulations. Alongside the warning and safety notices in this manual the relevant safety, accident prevention and environmental regulations must also be applied. In particular the users of the equipment:

- must be informed of the relevant job safety requirements
- must work to the defined responsibilities for operation, maintenance and cleaning of the equipment
- before starting work must have read and understood the operating manual
- must use the designated and recommended safety equipment.

Furthermore, anyone working with the equipment is responsible for ensuring that the device is at all times technically fit for use.

1.7.3 Responsibility of the operator

Operator is any natural or legal person who uses the equipment or delegates the usage to a third party, and is responsible during its usage for the safety of the user, other personnel or third parties.

The equipment is in industrial operation. Therefore the operators are governed by the legal safety regulations. Alongside the warning and safety notices in this manual the relevant safety, accident prevention and environmental regulations must also be applied. In particular the operator has to

- be acquainted with the relevant job safety requirements
- identify other possible dangers arising from the specific usage conditions at the work station via a risk assessment
- introduce the necessary steps in the operating procedures for the local conditions
- regularly check that the operating procedures are current
- update the operating procedures where necessary to reflect changes in regulation, standards or operating conditions.
- define clearly and unambiguously the responsibilities for operation, maintenance and cleaning of the equipment.
- ensure that all employees who use the equipment have read and understood the manual. Furthermore the users are to be regularly schooled in working with the equipment and the possible dangers.
- provide all personnel who work with the equipment with the designated and recommended safety equipment

Furthermore, the operator is responsible for ensuring that the device is at all times technically fit for use.

1.7.4 User requirements

Any activity with equipment of this type may only be performed by persons who are able to work correctly and reliably and satisfy the requirements of the job.

- Persons whose reaction capability is negatively influenced by e.g. drugs, alcohol or medication may not operate the equipment.
- Age or job related regulations valid at the operating site must always be applied.

Danger for unqualified users

Improper operation can cause person or object damage. Only persons who have the necessary training, knowledge and experience may use the equipment.

Delegated persons are those who have been properly and demonstrably instructed in their tasks and the attendant dangers.

Qualified persons are those who are able through training, knowledge and experience as well as knowledge of the specific details to carry out all the required tasks, identify dangers and avoid personal and other risks.

1.7.5 Alarm signals

The equipment offers various possibilities for signalling alarm conditions, however, not for danger situations. The signals may be optical (on the display as text) acoustic (piezo buzzer) or electronic (pin/status output of an analog interface). All alarms will cause the device to switch off the DC input.

The meaning of the signals is as follows:

Signal **OT** (OverTemperature)	• Overheating of the device • DC input will be switched off • Non-critical
Signal **OVP** (OverVoltage)	• Overvoltage shutdown of the DC input occurs due to high voltage entering the device • Critical! The device and/or the load could be damaged
Signal **OCP** (OverCurrent)	• Shutdown of the DC input due to excess of the preset limit • Non-critical, protects the source from excessive current drain
Signal **OPP** (OverPower)	• Shutdown of the DC input due to excess of the preset limit • Non-critical, protects the source from excessive power drain
Signal **PF** (Power Fail)	• DC input shutdown due to AC undervoltage or internal auxiliary supply defect • Critical on AC overvoltage! AC mains input circuit could be damaged

1.8 Technical data

1.8.1 Approved operating conditions

- Use only inside dry buildings
- Ambient temperature 0-50 °C
- Operational altitude: max. 2000 m above sea level
- Maximum 80% humidity, not condensing

1.8.2 General technical data

Display: Color TFT display, 480pt x 128pt

Controls: 2 rotary knobs with pushbutton functions, 7 pushbuttons

The nominal values for the device determine the maximum adjustable ranges.

1.8.3 Specific technical data

400 W	Model		
	EL 3080-60 B	*EL 3200-25 B*	*EL 3500-10 B*
AC mains supply			
Supply voltage	90...264 V AC		
Connection type	Wall socket		
Frequency	45...65 Hz		
Fuse	T 2 A		
Power consumption	Max. 40 W		
Inrush current @ 230 V	Ca. 23 A		
Leak current	< 3.5 mA		
DC Input			
Max. input voltage U_{Max}	80 V	200 V	500 V
Steady input power P_{Nom}	400 W	400 W	400 W
Max. input current I_{Max}	60 A	25 A	10 A
Overvoltage protection range	0...1.03 * U_{Max}	0...1.03 * U_{Max}	0...1.03 * U_{Max}
Overcurrent protection range	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}
Overpower protection range	0...1.1 * P_{Nom}	0...1.1 * P_{Nom}	0...1.1 * P_{Nom}
Max. allowed input voltage	88 V	220 V	550 V
Min. input voltage for I_{Max}	Approx. 2.6 V	Approx. 1.9 V	Approx. 4.7 V
Inpit capacitance	1.5 µF || (2.2 µF + 1 Ω)	880 nF || (1.5 µF + 0.47 Ω)	530 nF || (1 µF + 1 Ω)
Temperature coefficient for set values Δ / K	Voltage / current: 100 ppm		
Voltage regulation			
Adjustment range	0...81.6 V	0...204 V	0...510 V
Stability at ΔI	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Accuracy (1 (at 23 ± 5°C)	≤ 0.1% U_{Max}	≤ 0.1% U_{Max}	≤ 0.1% U_{Max}
Display: Adjustment resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (2	≤ 0.1%		
Remote sensing compensation	Max. 5% U_{Max}		
Current regulation			
Adjustment range	0...61.2 A	0...25.5 A	0...10.2 A
Stability at ΔU	< 0.1% I_{Max}	< 0.1% I_{Max}	< 0.1% I_{Max}
Accuracy (1 (at 23 ± 5°C)	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}
Display: Adjustment resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (2	≤0.1%		
Power regulation			
Adjustment range	0…408 W	0…408 W	0…408 W
Accuracy (1 (at 23 ± 5°C)	< 1% P_{Nom}	< 1% P_{Nom}	< 1% P_{Nom}
Display: Adjustment resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (2	≤ 0.2%		
Resistance regulation			
Adjustment range	0.12…40 Ω	1…340 Ω	6…2000 Ω
Accuracy (3 (at 23 ± 5°C)	≤1% of maximum resistance + 0.3% of maximum current		
Display: Adjustment resolution	See section *„1.9.5.4. Resolution of the displayed values“*		

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
(2 The display accuracy adds to the accuracy of the corresponding value on the DC input
(3 Includes the accuracy of the display actual value

400 W	Model		
	EL 3080-60 B	*EL 3200-25 B*	*EL 3500-10 B*
Analog interface (optional) (1			
Set value inputs	U, I, P, R		
Actual value output	U, I		
Control signals	DC on/off, Remote control on/off, R mode on/off		
Status signals	CV, OVP, OT		
Insulation			
Input (DC) to enclosure	DC minus: permanent max. ±400 V DC plus: permanent max. ±400 V + max. input voltage		
Input (AC) to input (DC)	Max. 2500 V, short-term		
Environment			
Cooling	Temperature controlled fans		
Ambient temperature	0..50 °C		
Storage temperature	-20...70 °C		
Digital interfaces			
Optionally available	IF-KE5 USB: 1x USB IF-KE5 USB/LAN: 1x USB + 1x LAN IF-KE5 USB/ANALOG: 1x USB + 1x Analog		
Terminals			
Rear side	AC input, analog interface (optional), USB (optional), Ethernet (optional)		
Front side	DC input, remote sensing		
Dimensions			
Enclosure (WxHxD)	260 x 88 x 325 mm		
Total (WxHxD)	308 x max. 195 x mind. 361 mm		
Standards	EN 61010-1:2011-07, EN 61000-6-2:2016-5, EN 61000-6-3:2011-09 Class B		
Weight	4 kg	4 kg	4 kg
Article number	35320205	35320206	35320207

(1 For technical specifications of the analog interface see *„3.5.4.4 Analog interface specification“ on page 37*

1.8.4 Views

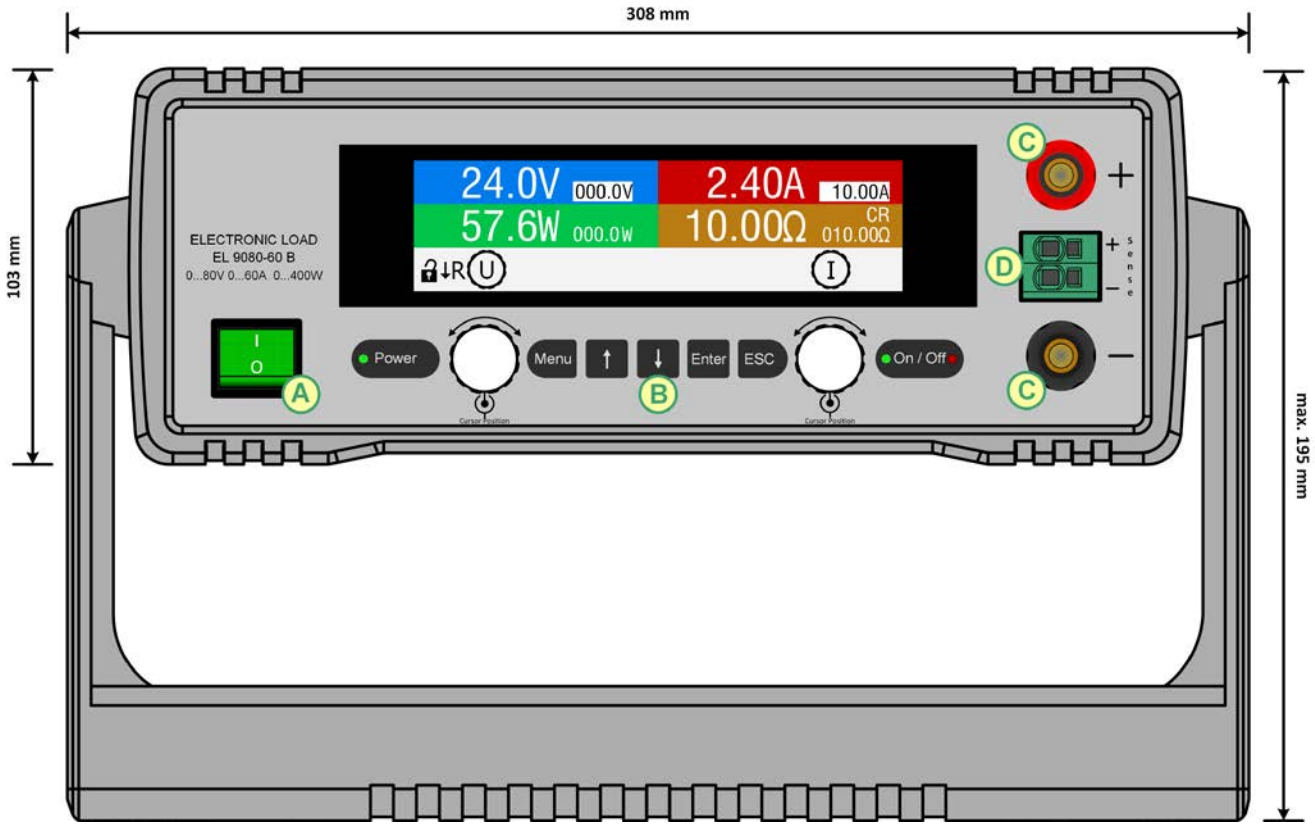


Figure 1 - Front side

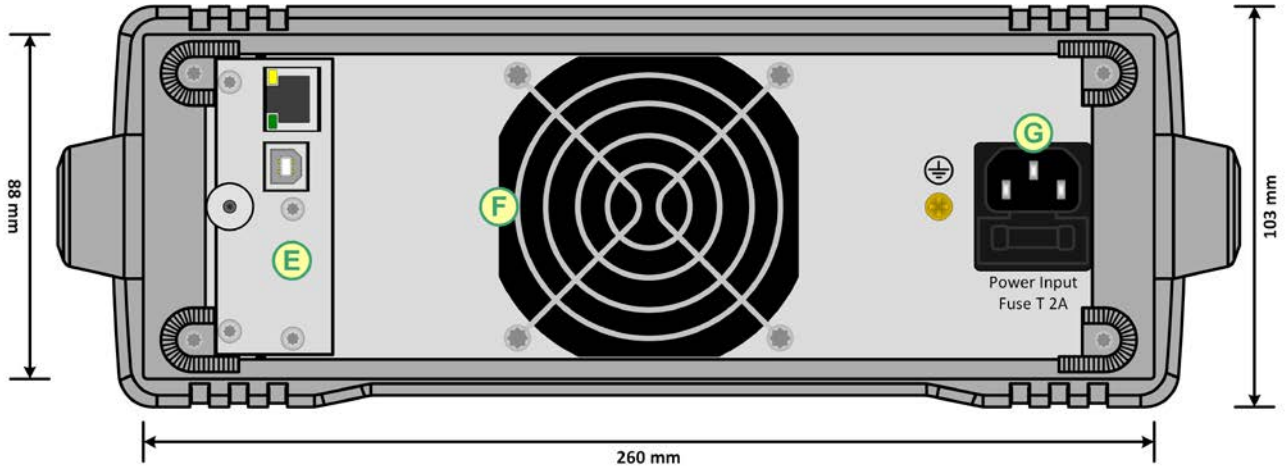


Figure 2 - Rear side

⚠	Do not loosen the grounding point (brass screw next to fuse holder G) in order to connect PE cables! The device is supposed to be grounded via the AC cord, while the grounding point is used to connect the enclosure to PE.

A - Power switch
B - Control panel
C - DC input
D - Remote sensing input
E - Remote control interfaces (optional, USB/Ethernet shown)
F - Fan exhaust
G - AC supply connection with fuse holder

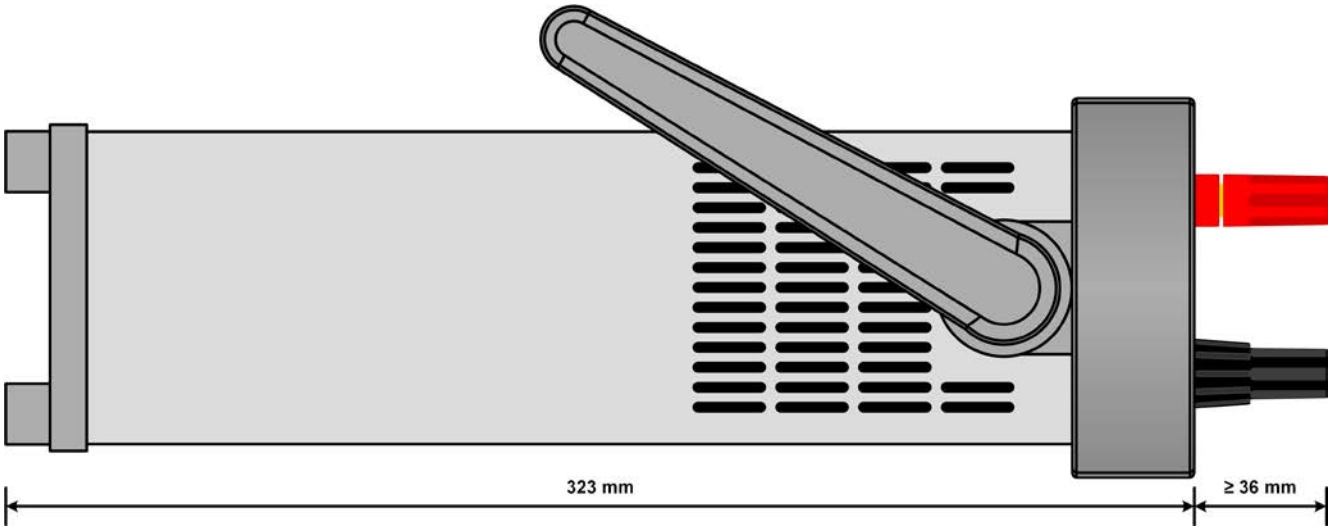


Figure 3 - Side view from left, horizontal position

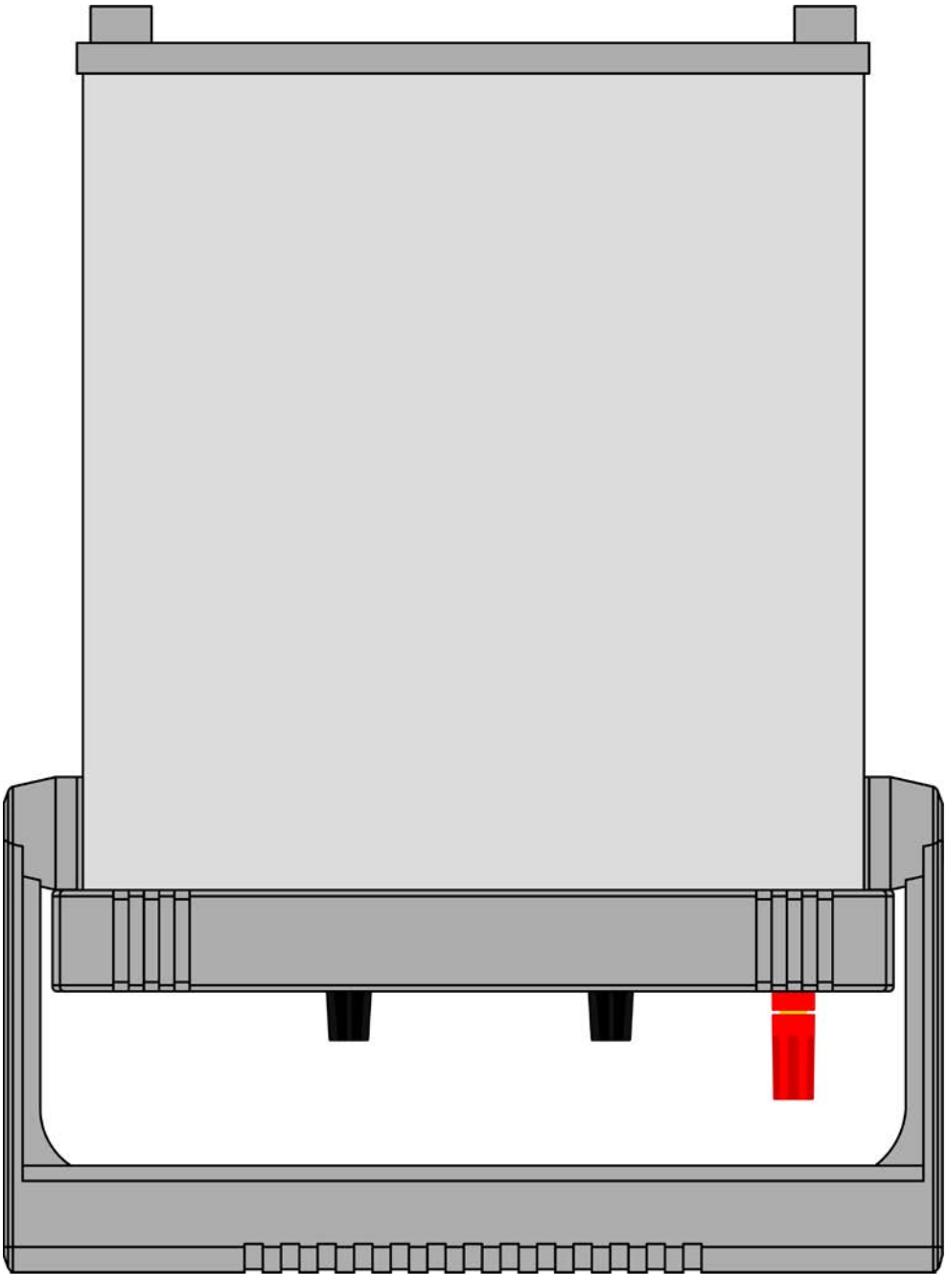


Figure 4 - Top view

1.8.5 Control elements

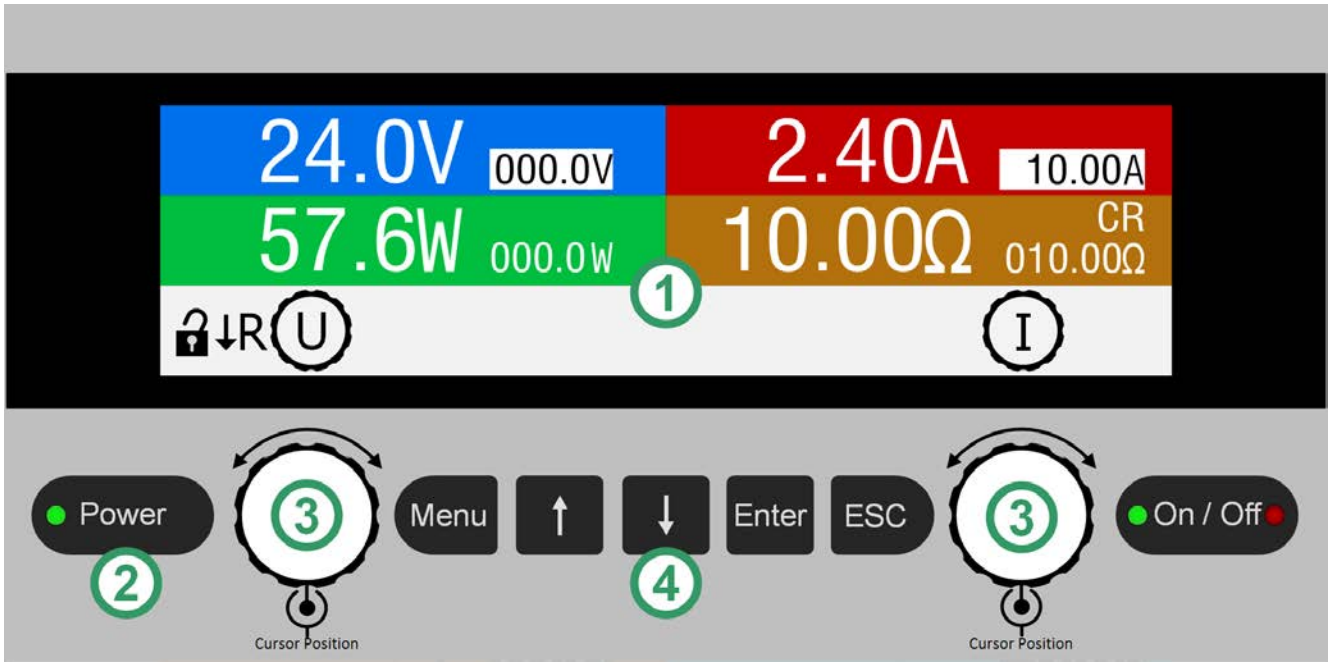


Figure 5 - Control Panel

Overview of the elements on the control panel

For a detailed description see section *„1.9.5. The control panel (HMI)“* and *„1.9.5.2. Rotary knobs“.*

(1)	**Colour display** Used for display of set values, menus, actual values, status and rotary knob assignment.	
(2)	**LED “Power”** Indicates different colours during the start of the device and once ready for operation, it turns green and remains for the period of operation.	
(3)	**Rotary knob with push button function** Left knob (turn): adjustment of voltage, power or resistance set value, or set parameter values in the menu Left knob (push): selection of the decimal position (cursor) of the currently assigned value Right knob (turn): adjusting the current set value, or setting parameter values in the menu Right knob (push): selection of the decimal position (cursor) of the currently assigned value	
(4)	**Pushbuttons**	
	Menu	Is used to access the device menu (while the DC input is off) or to quick access the HMI lock feature (while the DC input is on)
	↑ ↓	Are used to navigate in the submenus of the device menu and to switch between parameters and values, as well as to switch the knob assignment in the main screen
	Enter	Is used to access submenus in the device menu, to submit changes of settings and values, as well as to unlock the HMI
	ESC	Is uses to exit menu pages and to cancel changes on values and settings
	On / Off	Is used to switch the DC input on or off during manual control, as well to start or stop a function. The two LEDs indicate the DC input condition all the time, no matter if during manual or remote control (green = on, red = off)

1.9 Construction and function

1.9.1 General description

The conventional, electronic DC loads of EL 3000 B series are the second generation of small desktop loads in the power class up to 400 W. Due to their compact size they're especially suitable for research laboratories, test applications or educational purposes.

Apart from basic functions of electronic loads, ramp bases waves, such as rectangular or triangular can be generated the integrated function generator.

For remote control using a PC the devices can be equipped with an optional, separately available and user-retrofittable interface card. There is a choice of three different types: USB, USB+Ethernet or USB+Analog. All interfaces are galvanically isolated from the device.

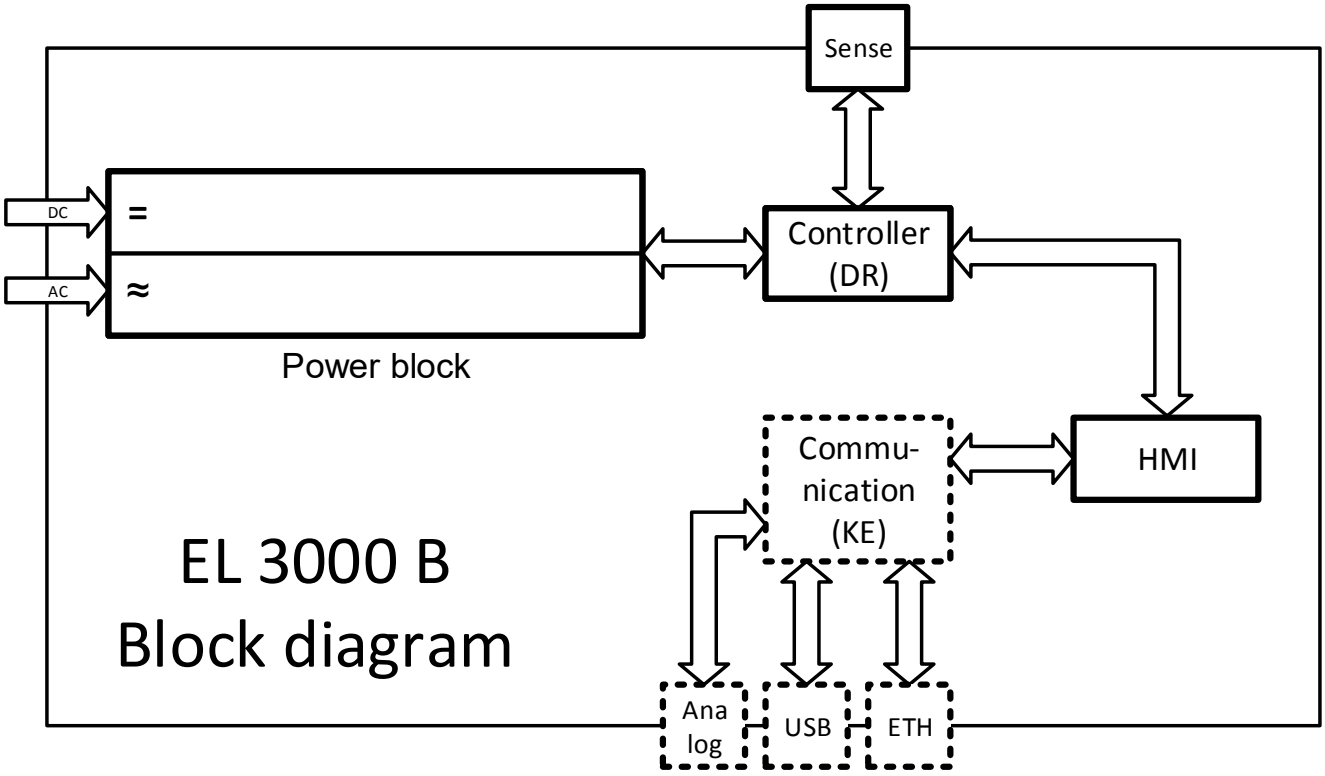
The standard carrying handle can serve as tilt stand, allowing for setup of different positions in order to make it easier to read from the display or access the control elements.

All models are controlled by microprocessors.

1.9.2 Block diagram

The block diagram illustrates the main components inside the device and their relationships.

There are digital, microprocessor controlled components (KE, DR, BE), which can be target of firmware updates. See below (dotted elements are optional components):



1.9.3 Scope of delivery

1 x Electronic load device

1 x USB stick with documentation and software

1 x Mains cord

1 x UK wall socket adapter or BS cord (only included in delivery to the UK)

1.9.4 Optional accessories

For these devices the following accessories are available:

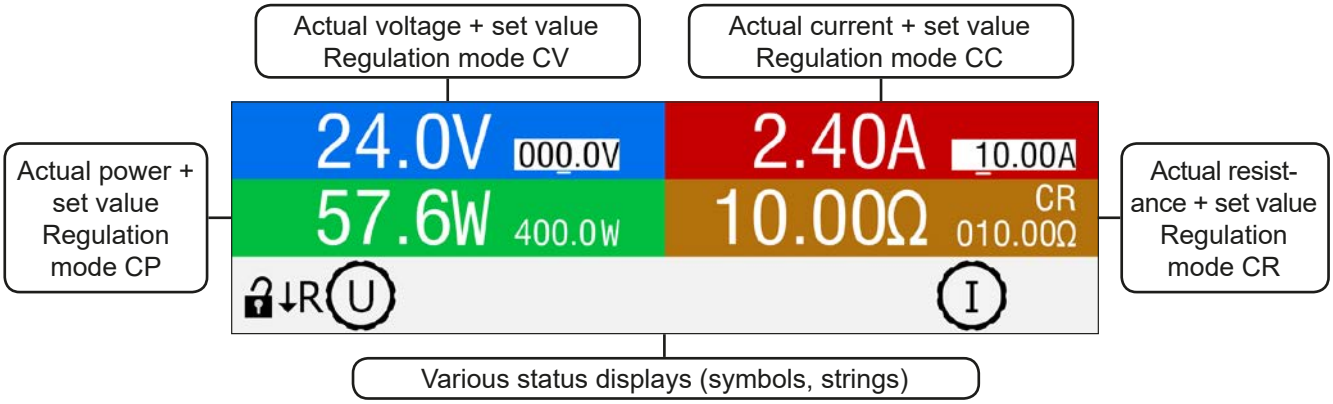
IF-KE5 USB Ordering nr. 33 100 232	Digital interface card with **USB port**. Can be ordered separately. Simple installation by the user on location. USB cable of 1.8 m length included.
IF-KE5 USB LAN Ordering nr. 33 100 233	Digital interface card with **USB port** and **Ethernet/LAN port**. Can be ordered separately. Simple installation by the user on location. USB cable of 1.8 m length included.
IF-KE5 USB Analog Ordering nr. 33 100 234	Digital/analog interface card with **USB port** and **15 pole analog D-Sub port**. Can be ordered separately. Simple installation by the user on location. USB cable of 1.8 m length included.

1.9.5 The control panel (HMI)

The HMI (**H**uman **M**achine **I**nterface) consists of a display, two rotary knobs and six pushbuttons.

1.9.5.1 Display

The graphic display is divided into a number of areas. In normal operation the upper part (⅔) is used to show actual and set values and thelower part (⅓) to display status information:



- **Actual / set values area (blue / green / red / orange)**

In normal operation the DC input values (large numbers) and set values (small numbers) for voltage, current, power and resistance are displayed. The resistance set value is, however, only displayed if resistance mode is activated.

While the DC input is switched on, the actual regulation mode **CV, CC, CP** or **CR** is displayed above to the corresponding set value, as shown in the figure above with example “CR”.

The set values can be adjusted by rotating the knobs below the display, whereas pushing the knobs is used to select the digit to be changed. Logically, the values are increased by clockwise turning and decreased by anti-clockwise turning. The current assignment of set a value to a knob is indicated by the corresponding set value being displayed in inverted form and also by the knob depiction in the status area showing the physical sign (U, I,P, R). In case these are not shown, the values can’t be adjusted manually, like in HMI lock or remote control.

General display and setting ranges:

Display	Unit	Range	Description
Actual voltage	V	0.2-125% U_{Nom}	Actual value of DC input voltage
Set value of voltage [1]	V	0-102% U_{Nom}	Set value for limiting the DC input voltage
Actual current	A	0.2-125% I_{Nom}	Actual value of DC input current
Set value of current [1]	A	0-102% I_{Nom}	Set value for limiting the DC input current
Actual power	W	0.2-125% P_{Peak}	Calculated actual value of input power, $P = U_{IN} * I_{IN}$
Set value of power [1]	W	0-102% P_{Peak}	Set value for limiting DC input power
Actual resistance	Ω	0...99.999 Ω	Calculated actual internal resistance, $R = U_{IN} / I_{IN}$
Set value of resistance [1]	Ω	x[2]-102% R_{Max}	Set value for the desired internal resistance
Adjustment limits 1	A,V,W	0-102% nom	U-max, I-min etc., related to the physical values
Adjustment limits 2	Ω	x[2]-102% nom	R-max
Protection settings 1	A,W	0-110% nom	OCP and OPP, related to the physical values
Protection settings 2	V	0-103% U_{Nom}	OVP, related to the physical values

[1] Valid also for values related to these physical quantities, such as OVD for voltage and UCD for current

[2] The minimum adjustable resistance set value varies depending on the model. See technical specifications in *1.8.3*

- **Status display (lower part)**

This area displays various status texts and symbols:

Display	Description
	The HMI is locked
	The HMI is unlocked
Remote:	The device is under remote control from....
Analog	....the (optional) analog interface
USB	....the (optional) USB port
Ethernet	....the (optional) Ethernet port
Local	The device has been locked by the user explicitly against remote control
Alarm:	Alarm condition which has not been acknowledged or still exists.
Function:	Function generator activated, function loaded
Stopped / Running	Status of the function generator resp. of the function

- **Area for assigning the rotary knobs**

The two rotary knobs below the display screen can be assigned to various functions. The status area in the display area depicts the actual assignments. After the device start and in the main screen the default assignment is voltage (left-hand knob) and current (right-hand knob):

These two values can then be adjusted manually. The decimal place to adjust is underlined, the currently selected value is displayed in inverted format:

. There are following possible assignments, whereas the right-hand knob remains assigned to the set value of current:

U I	**P I**	**R I**
Left rotary knob: voltage Right rotary knob: current	Left rotary knob: power Right rotary knob: current	Left rotary knob: resistance Right rotary knob: current (only with R mode activated)

The other set values can't be adjusted directly, until the assignment is changed. This is done using the "arrow down" button, as depicted by this symbol next to the corresponding knob depiction:

. With this being shown, the current assignment is voltage and can be changed to resistance, if resistance mode is activated, else to power.

1.9.5.2 Rotary knobs

As long as the device is in manual operation the two rotary knobs are used to adjust set values as well as setting the parameters in the "Menu". For a detailed description of the individual functions see section *„3.4 Manual operation" on page 29*.

1.9.5.3 Button function of the rotary knobs

The rotary knobs also have a pushbutton function which is used anywhere during value adjustment to shift the cursor as shown:

1.9.5.4 Resolution of the displayed values

In the display, set values can be adjusted with a fixed step width. The number of decimal places depends on the device model. The values have 4 or 5 digits. Actual and set values always have the same number of digits.

Adjustment resolution and number of digits of set values in the display:

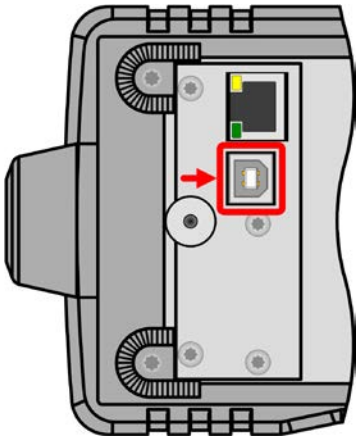
Voltage, OVP, U-min, U-max		
Nominal	Digits	Min. step width
80 V	4	0.01 V
200 V	4	0.1 V
500 V	4	0.1 V

Current, OCP, I-min, I-max		
Nominal	Digits	Min. step width
10 A	4	0.01 A
25 A	4	0.01 A
60 A	4	0.01 A

Power, OPP, P-max		
Nominal	Digits	Min. step width
400 W	4	0.1 W

Resistance, R-max		
Nominal	Digits	Min. step width
40 Ω	5	0.001 Ω
340 Ω	5	0.01 Ω
2000 Ω	5	0.1 Ω

1.9.6 USB port (optional)



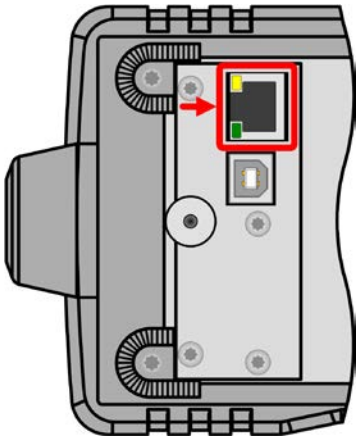
On the rear side of the device there is a slot to install one out of three types of optionally available, user-retrofittable interface cards. Also see section *1.9.4*. All three types feature an USB port.

The USB port is for communication with the device and for firmware updates. The USB cable (included with the interface card) can be used to connect the device to a PC (USB 2.0 or 3.0). The driver is delivered on the included USB stick and installs a virtual COM port. Details for remote control can be found on the web site of Elektro-Automatik or also on the USB stick.

The device can be addressed via this port either using the international standard ModBus RTU protocol or by SCPI language. The device recognises the message protocol automatically.

When requesting remote control via the USB port it has no priority over any other digital or analog interface and can, therefore, only be used alternatively to these. However, monitoring is always available.

1.9.7 Ethernet port (optional)



On the rear side of the device there is a slot to install one out of three types of optionally available, user-retrofittable interface cards. Also see section *1.9.4*. One of the types features an Ethernet/LAN port, plus an USB port.

The Ethernet port is for communication with the device in terms of remote control or monitoring over longer distances than possible with USB. The user has basically two options of access:

1. A website (HTTP, port 80) which is accessible in a standard browser under the IP or the host name given for the device. This website offers to configuration page for network parameters, as well as a input box for SCPI commands.

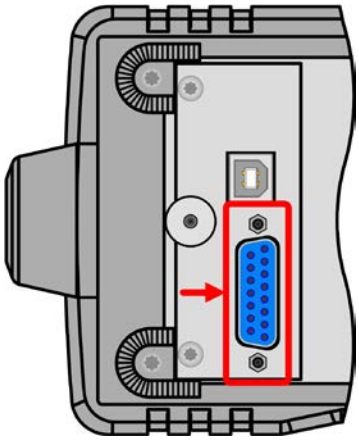
2. TCP/IP access via a freely selectable port (except 80 and other reserved ports). The standard port for this device is 5025. Via TCP/IP and this port, communication to the device can be established in most of the common programming languages.

Using the Ethernet port, the device can either be controlled by commands from SCPI or ModBus RTU protocol, while automatically detecting the type of message.

The network setup can be done manually or by DHCP. The transmission speed is set to “Auto negotiation” and means it can use 10MBit/s or 100MBit/s. 1GB/s isn’t supported. Duplex mode is always full duplex.

When requesting remote control via the Ethernet port it has no priority over the USB port and can, therefore, only be used alternatively to these. However, monitoring is always available.

1.9.8 Analog interface (optional)



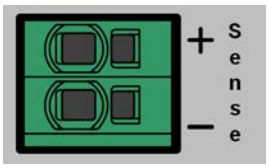
On the rear side of the device there is a slot to install one out of three types of optionally available, user-retrofittable interface cards. Also see section *1.9.4*. One of the types features an analog 15 pole D-Sub type connector, plus an USB port.

This 15 pole socket is provided for remote control of the device via analog and-digital switch signals.

When requesting remote control via the analog port it has no priority over the digital interface and can, therefore, only be used alternatively to these. However, monitoring is always available.

The input voltage range of the set values and the output voltage range of the monitor values, as well as reference voltage level can be switched in the settings menu of the device between 0-5 V and 0-10 V, in each case for 0-100%.

1.9.9 “Sense” connector (remote sensing)



In order to compensate for voltage drops along the DC cables, the **Sense** input (between the DC input terminals) can be connected to the source. The device will automatically detect when the sense input is wired (Sense+) and compensate the input voltage accordingly.

The maximum possible compensation is given in the technical specifications.

2. Installation & commissioning

2.1 Storage

2.1.1 Packaging

It is recommended to keep the complete transport packaging for the lifetime of the device for relocation or return to Elektro-Automatik for repair. Otherwise the packaging should be disposed of in an environmentally friendly way.

2.1.2 Storage

In case of long term storage of the equipment it's recommended to use the original packaging or similar. Storage must be in dry rooms, if possible in sealed packaging, to avoid corrosion, especially internal, through humidity.

2.2 Unpacking and visual check

After every transport, with or without packaging, or before commissioning, the equipment should be visually inspected for damage and completeness using the delivery note and/or parts list (see section *„1.9.3. Scope of delivery“*). An obviously damaged device (e.g. loose parts inside, damage outside) must under no circumstances be put in operation.

2.3 Installation

2.3.1 Safety procedures before installation and use

- When installing the device in a 19" rack using the optionally available mount frame, rails suitable for the total weight of the device are to be used (see *„1.8.3. Specific technical data“*).
- Before connecting to the mains ensure that the connection is as shown on the product label. Overvoltage on the AC supply can cause equipment damage.
- Before connecting a voltage source to the DC input make sure, that the source can't generate a voltage higher than specified for a particular model or install measures which can prevent damaging the device by overvoltage input.

2.3.2 Preparation

Mains connection with an EL 3000 B series device is done via the included 1.5 meters long 3 pole mains cord.

Dimensioning of the DC wiring to the source has to reflect the following:

- The cable cross section should always be specified for at least the maximum current of the device.
- Continuous operation at the approved limit generates heat which must be removed, as well as voltage loss which depends on cable length and heating. To compensate for these the cable cross section should be increased and/or the cable length reduced.

2.3.3 Installing the device

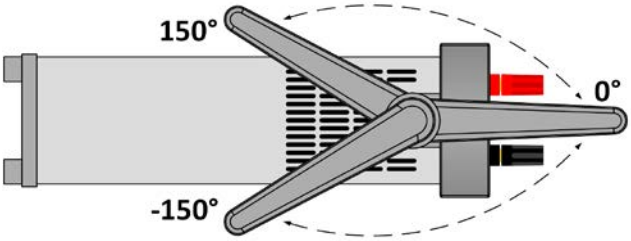
- Select the location for the device so that the connection to the source is as short as possible.
- Leave sufficient space behind the equipment, minimum 30 cm, for ventilation of warm air that will be exhausted
- Never obstruct the air inlets on the sides!
- In case the handle is used to bring the device into an uplifted position, never place any objects onto the top of the unit!

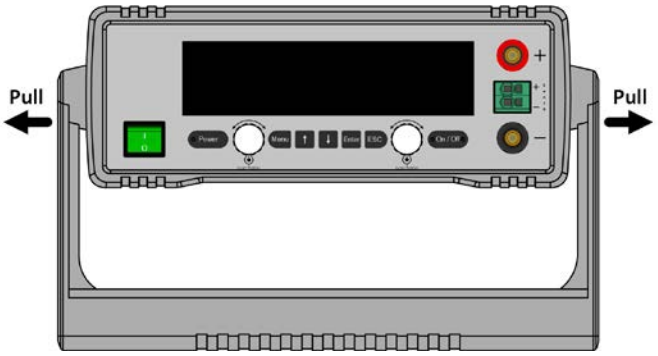
2.3.3.1 The handle

The included handle isn't only used to carry the device, it can also uplift the device's front for easier access to knobs and buttons or better display readability.

The handle can be rotated into various positions in an angle of 300°, such as a variable position (60...150°), 0°, -45°, -90° and -150°.

It is rotated by pulling on both sides of the handle first in order to loosen the detent and then moving the handle around its axis.

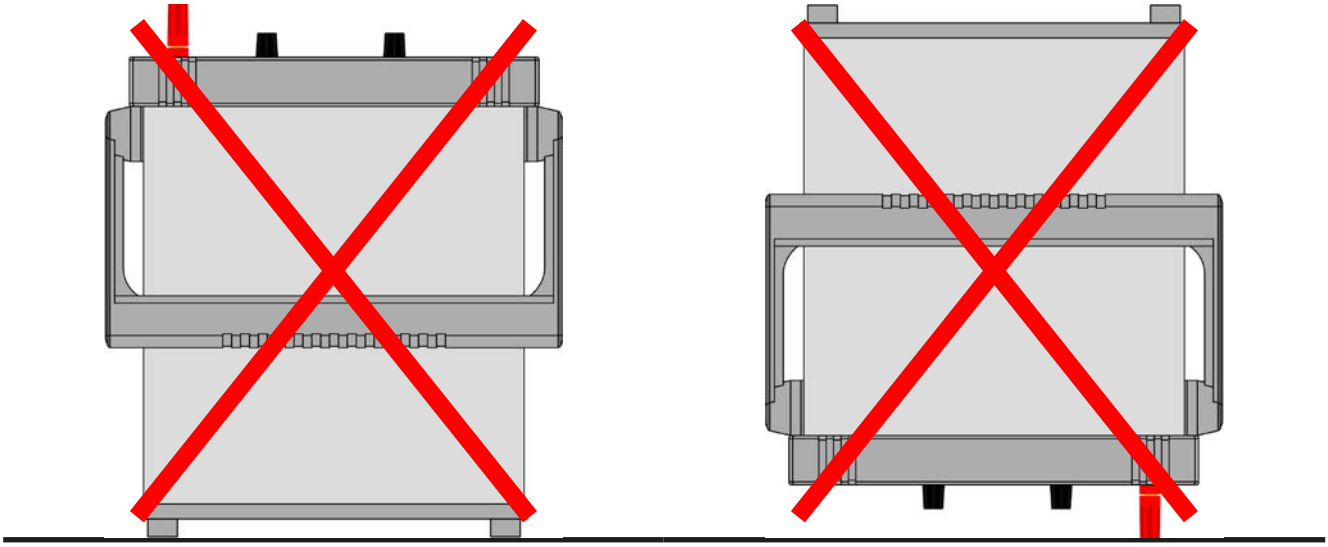




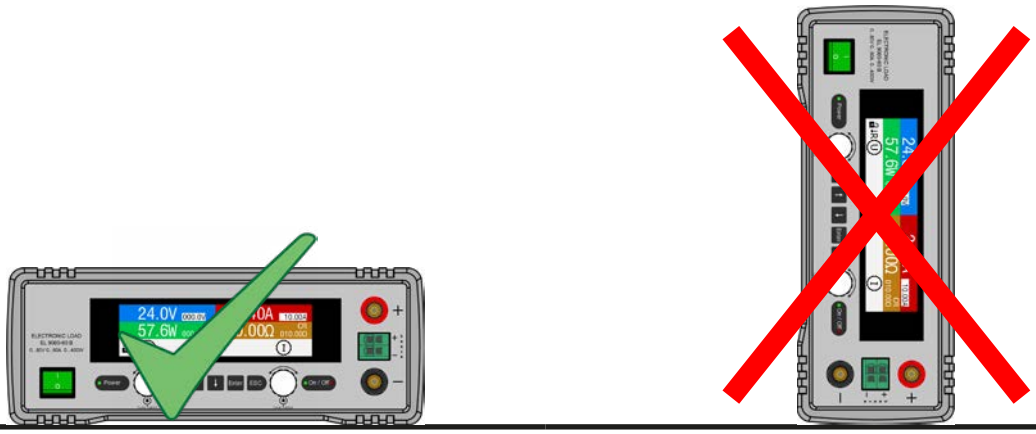
2.3.3.2 Placement on horizontal standing surfaces

The device is designed as a desktop unit and should only be operated in horizontal position on horizontal surfaces, which are capable of securely carrying the weight of the device.

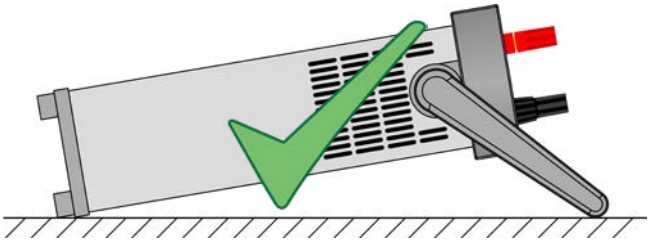
Acceptable and inacceptable operating positions:



Standing surface



Standing surface

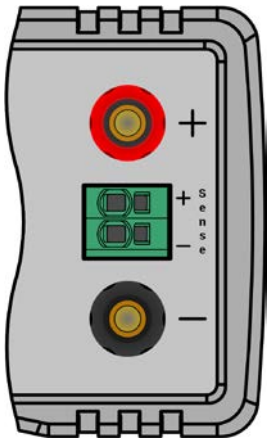


Standing surface (handle in -45° position)

2.3.4 Connection to DC sources

- When using the model which is rated for 60 A, attention has to be paid to where the source is connected on the DC input terminals. The front 4mm banana plug hole is only rated for **max. 32 A**!
- Connection of voltage sources which can generate a voltage higher than 110% nominal of the device model isn't allowed!
- Connection of voltage sources with reversed polarity isn't allowed!

The DC load input is on the front side of the device and isn**'t** protected by a fuse. The cross section of the connection cable is determined by the current consumption, cable length and ambient temperature.



For cables **up to 5 m** and average ambient temperature up to 50°C, we recommend:

up to **10 A**: 0.75 mm² (AWG18) up to **25 A**: 4 mm² (AWG10)

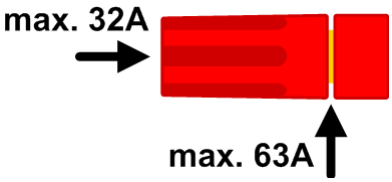
up to **60 A**: 16 mm² (AWG4)

per lead (multi-conductor, insulated, openly suspended). Single cables of, for example, 16 mm² may be replaced by e.g. 2x 6 mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

2.3.4.1 Possible connections on the DC input

The DC input on the front is of type clamp & plug and can be used with:

- 4 mm system plugs (Büschel, banana, safety) for **max. 32 A**
- Spade lugs (6 mm or bigger)
- Soldered cable ends (only recommended for small currents up to 10 A)



When using any type of lugs or cable end sleeves, only use those with insulation to ensure electric shock protection!

2.3.5 Grounding of the DC input

The device can always be grounded on the DC minus pole, i.e. can be directly connected to PE. The DC plus pole, however, if it's to be grounded, may only be so for input voltages up to 400 V, because the potential of the minus pole is shifted into negative direction by the value of the input voltage. Also see technical specification sheets in *1.8.2*, item "Insulation".

For this reason, for all models which can support an input voltage higher than 400 V grounding of the DC plus pole isn't allowed.

- Do not ground the DC plus pole on any model with >400 V nominal voltage
- If grounding one of the input poles ensure that no output pole of the source (e.g. power supply) is grounded. This could lead to a short-circuit!

2.3.6 Connection of remote sensing

- Remote sensing is only effective during constant voltage operation (CV) and for other regulation modes the sense input should be disconnected, if possible, because connecting it generally increases the oscillation tendency.
- The cross section of the sensing cables is noncritical. Recommendation for cables up to 5 m: use at least 0.5 mm²
- Sensing cables should be twisted and laid close to the DC cables to damp oscillation. If necessary, an additional capacitor can be installed at the source to eliminate oscillation
- Sensing cables must be connected + to + and - to - at the source, otherwise the sense input of the electronic load can be damaged. For an example see *Figure 6* below.

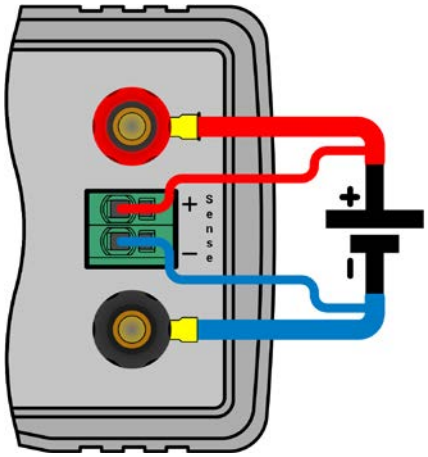


Figure 6 - Example for remote sensing wiring

The connector Sense is a clamp terminal. It means for the remote sensing cables:

- Insert cables: crimp sleeves onto the cable ends and simply push them into the bigger square hole
- Remove cables: use a small flat screwdriver and push into the smaller square hole next to the bigger one to loosen the cable clamp, then remove cable end

2.3.7 Connecting the analog interface

An analog interface in form of a pluggable interface card is optionally available, can be retrofitted by the user on location into the rear side located slot and offers a 15 pole D-Sub connector. To connect it to a control hardware (PC, PLC, electronic circuit), a standard D-Sub plug is required (not included with the interface). It is generally advisable to switch the device completely off before connecting or disconnecting this connector, but at least the DC input.

The analog interface is galvanically isolated from the device internally. Therefore do not connect any ground of the analog interface (AGND) to the DC minus input as this will cancel the galvanic isolation.

2.3.8 Connecting the USB port

An USB interface in form of a pluggable interface card is optionally available and can be retrofitted by the user on location into the rear side located slot. Depending on the type of the card it only offers the USB port or also has an extra port (LAN or analog).

In order to remotely control the device via this port, connect the device with a PC using the included USB cable and switch the device on.

2.3.8.1 Driver installation (Windows)

On the initial connection with a PC the operating system will identify the device as new hardware and will try to install a driver. The required driver is for a Communication Device Class (CDC) device and is usually integrated in current operating systems such as Windows 7 or 10. But it's strongly recommended to use the included driver installer (on USB stick) to gain maximum compatibility of the device to our softwares.

2.3.8.2 Driver installation (Linux, MacOS)

We can't provide drivers or installation instructions for these operating systems. Whether a suitable driver is available is best found out by searching the Internet. With newer versions of Linux or MacOS, a generic CDC driver should be "on board".

2.3.8.3 Alternative drivers

In case the CDC drivers described above are not available on your system, or for some reason do not function correctly, commercial suppliers can help. Search the Internet for suppliers using the keywords “cdc driver windows“ or “cdc driver linux“ or “cdc driver macos“.

2.3.9 Connecting the LAN port

An Ethernet/LAN interface in form of a pluggable interface card is optionally available and can be retrofitted by the user on location into the rear side located slot.

Connection to a remote host of any type (switch, server, PC) is done with standard Cat 5 Ethernet cables (patch cable, not included with the interface card). There are several parameters to set up proper network connection. Refer to section *3.4.3* for more information.

2.3.10 Initial commission

For the first start-up after purchasing and installing the device, the following procedures have to be executed:

- Confirm that the connection cables to be used are of a satisfactory cross section!
- Check if the factory settings of set values, safety and monitoring functions and communication are suitable for your intended application of the device and adjust them if required, as described in the manual!
- In case of remote control via PC, read the additional documentation for interfaces and software!
- In case of remote control via the analog interface, read the section in this manual concerning analog interfaces!

During every start the device show a language selection screen for a few seconds where you can quickly switch the display language. This can also be done later, via the MENU:

2.3.11 Commission after a firmware update or a long period of non use

In case of a firmware update, return of the equipment following repair or a location or configuration change, similar measures should be taken to those of initial start up. Refer to *„2.3.10. Initial commission“.*

Only after successful checking of the device as listed may it be operated as usual.

3. Operation and application

3.1 Personal safety

- In order to guarantee safety when using the device, it's essential that only persons operate the device who are fully acquainted and trained in the required safety measures to be taken when working with dangerous electrical voltages
- For models which accept dangerous voltages, a protection against unwanted physical contact has to be installed on the DC input
- Whenever the DC input is being re-configured, you must switch off the source or, better, disconnect it!

3.2 Operating modes

An electronic load is internally controlled by different control or regulation circuits which shall limit current or power to the adjusted values and hold them constant, if possible. These circuits follow typical laws of control systems engineering, resulting in different operating modes. Every operating mode has its own characteristics which are explained below in short form.

3.2.1 Voltage regulation / Constant voltage

Constant voltage operation (CV) or voltage regulation is a subordinate operating mode of electronic loads. In normal operation, a voltage source is connected to electronic load, which represents a certain input voltage for the load. If the set value for the voltage in constant voltage operation is higher than the actual voltage of the source, the value can't be reached. The load will then take no current from the source. If the voltage set value is lower than the input voltage then the load will attempt to drain enough current from the source to achieve the desired voltage level. If the resulting current exceeds the maximum possible or adjusted current value or the total power according to $P = U_{IN} * I_{IN}$ is reached, the load will automatically switch to constant current or constant power operation, whatever comes first. Then the adjusted input voltage can no longer be achieved.

While the DC input is switched on and constant voltage mode is active, then the condition "CV mode active" will be shown on the graphics display by the abbreviation **CV**, as well it will be passed as a signal to the analog interface and stored as internal status which can be read via digital interface.

3.2.1.1 Speed of the voltage controller

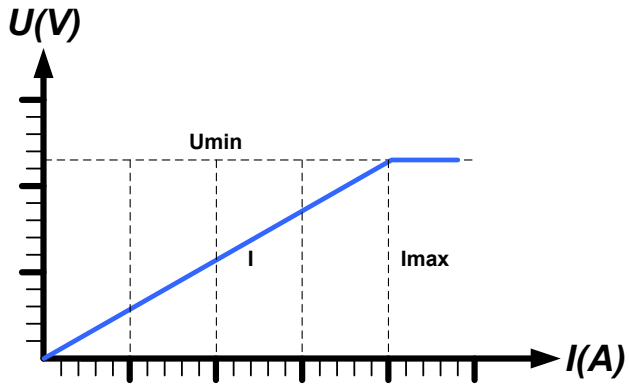
The internal voltage controller can be switched between **Slow** and **Fast** (see *„3.4.3.2. Menu "General Settings""*). Factory default value is **Slow**. Which setting to select depends on the actual situation in which the device is going to be operated, but primarily it depends of the type of voltage source. An active, regulated source such as a switching mode power supply has its own voltage control circuit which works concurrently to the load's circuit. Both might work against each other and lead to oscillation. If this occurs it's recommended to set the controller speed to "Slow".

In other situations, e.g. operating the function generator and applying various functions to the load's input voltage and setting of small time increments, it might be necessary to set the voltage controller to **Fast** in order to achieve the expected results.

3.2.1.2 Minimum voltage for maximum current

Due to technical reasons, all models in this series have a minimum internal resistance that makes the unit to be supplied with a minimum input voltage (U_{MIN}) in order to be able to draw the full current (I_{MAX}). This minimum input voltage varies from model to model and is listed in the technical specifications. If less voltage than U_{MIN} is supplied, the load proportionally draws less current, which can be calculated easily.

See principle view to the right.



3.2.2 Current regulation / constant current / current limitation

Current regulation is also known as current limitation or constant current mode (CC) and is fundamental to the normal operation of an electronic load. The DC input current is held at a predetermined level by varying the internal resistance according to Ohm's law R = U / I such that, based on the input voltage, a constant current flows. Once the current has reached the adjusted value, the device automatically switches to constant current mode. However, if the power consumption reaches the adjusted power level, the device will automatically switch to power limitation and adjust the input current according to $I_{MAX} = P_{SET} / U_{IN}$, even if the maximum current set value is higher. The current set value, as determined by the user, is always and only an upper limit.

While the DC input is switched on and constant current mode is active, the condition "CC mode active" will be shown on the graphics display by the abbreviation **CC**, as well it will be passed as a signal to the analog interface and stored as internal status which can be read via digital interface.

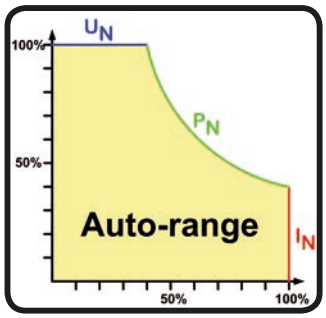
3.2.3 Resistance regulation / constant resistance

Inside electronic loads, whose operating principle is based on a variable internal resistance, constant resistance mode (CR) is almost a natural characteristic. The load attempts to set the internal resistance to the user defined value by determining the input current depending on the input voltage according to Ohm's law $I_{IN} = U_{IN} / R_{SET}$. The internal resistance is naturally limited between almost zero and maximum (resolution of current regulation too inaccurate). As the internal resistance can't have a value of zero, the lower limit is defined to an achievable minimum. This ensures that the electronic load, at very low input voltages, can consume a high input current from the source, up to the maximum.

While the DC input is switched on and constant resistance mode is active, the condition "CR mode active" will be shown on the graphics display by the abbreviation **CR**, as well it will be stored as internal status which can be read via digital interface.

3.2.4 Power regulation / constant power / power limitation

Power regulation, also known as power limitation or constant power (CP), limits the DC input power of the device at the adjusted value, so that the current flowing from the source, together with the input voltage, achieves the desired value. Power limitation then limits the input current according to $I_{IN} = P_{SET} / U_{IN}$ as long as the power source is able to provide this power.



Power limitation operates according to the auto-range principle such that at lower input voltages higher current can flow and vice versa, in order to maintain constant power within the range P_N (see diagram to the right).

While the DC input is switched on and constant power operation is active, the condition "CP mode active" will be shown on the graphic display by the abbreviation **CP**, as well it will be stored as internal status which can be read via digital interface.

Constant power operation impacts the internal set current value. This means that the maximum set current may not be reachable if the set power value according to I = P / U sets a lower current. The user defined and displayed set current value is always the upper limit only.

3.2.5 Dynamic characteristics and stability criteria

The electronic load is characterised by short rise and fall times of the current, which are achieved by a high bandwidth of the internal regulation circuit.

In case of testing sources with own regulation circuits at the load, like for example power supplies, a regulation instability may occur. This instability is caused if the complete system (feeding source and electronic load) has too little phase and gain margin at certain frequencies. 180 ° phase shift at > 0dB amplification fulfils the condition for an oscillation and results in instability. The same can occur when using sources without own regulation circuit (eg. batteries), if the connection cables are highly inductive or inductive-capacitive.

The instability isn't caused by a malfunction of the load, but by the behaviour of the complete system. An improvement of the phase and gain margin can solve this. In practice, a capacity is directly connected to the DC input of the load. The value to achieve the expected result isn't defined and has to be found out. We recommend:

80 V models: 1000 µF....4700 µF
200 V models: 100 µF...470 µF
360 V models: 68 µF...220 µF
500 V models: 47 µF...150 µF
750 V models: 22 µF...100 µF

3.3 Alarm conditions

This section only gives an overview about device alarms. What to do in case your device indicates an alarm condition is described in section „3.6. Alarms and monitoring“.

As a basic principle, all alarm conditions are signalled optically (text + message in the display) and acoustically (if activated), as well status and alarm counter readable via an optional, digital interface. In addition, the alarms OT, PF and OVP are reported as signals on the optional, analogue interface. For later acquisition, the alarm counter can also be shown on display.

3.3.1 Power Fail

Power Fail (PF) indicates an alarm condition which may have various causes:

- AC input voltage too low (mains undervoltage, mains failure)
- Defect in the input circuit (PFC)

As soon as a power fail occurs, the device will stop to sink power and switch off the DC input. In case the power fail was an undervoltage and is gone later on, the alarm will vanish from display and doesn't require to be acknowledged.

The condition of the DC input after a gone PF alarm can be determined in the MENU. See *3.4.3.*

Switching off the device with the power switch can't be distinguished from a mains blackout and thus the device will signalise a PF alarm every time it's switched off. This can be ignored.

3.3.2 Overtemperature

An overtemperature alarm (OT) can occur from an excess temperature inside the device and causes it to stop sinking power temporarily. This can occur due to a defect of the internal fan regulation or due to excessive ambient temperature.

After cooling down, the device will automatically continue to work, while the condition of the DC input remains and the alarm doesn't require to be acknowledged.

3.3.3 Overvoltage

An overvoltage alarm (OVP) will switch off the DC input and can occur if:

- the connected voltage source provides a higher voltage to the DC input than set in the overvoltage alarm threshold (OVP)

This function serves to warn the user of the electronic load acoustically or optically that the connected voltage source has generated an excessive voltage and thereby could damage or even destroy the input circuit and other parts of the device.

The device isn't fitted with protection from external overvoltage and could even be damaged when not powered.

3.3.4 Overcurrent

An overcurrent alarm (OCP) will switch off the DC input and can occur if:

- The input current in the DC input exceeds the adjusted OCP limit.

This function serves to protect the voltage and current source so that this isn't overloaded and possibly damaged, rather than offering protection to the electronic load.

3.3.5 Overpower

An overpower alarm (OPP) will switch off the DC input and can occur if:

- the product of the input voltage and input current in the DC input exceeds the adjusted OPP limit.

This function serves to protect the voltage and current source so it this isn't overloaded and possibly damaged, rather than offering protection to the electronic load.

3.4 Manual operation

3.4.1 Powering the device

The device should, as far as possible, always be switched on using the toggle switch on the front of the device. After switching on, the display will first show the company logo, manufacturer's name and address, device type, firmware version(s), serial number and item number.

In setup (see section *„3.4.3. Configuration via MENU“),* in the second level menu **General settings** is an option **DC input after power ON** in which the user can determine the condition of the DC input after power-up. Factory setting here is **OFF**, meaning that the DC input will always be switched off on power-up, while **Restore** means that the last condition of the DC input will be restored, either on or off. All set values are also restored.

For the time of the start phase the analog interface can signal undefined statuses on the output pins such as ALARMS or OVP. These signals must be ignored until the device has finished booting and is ready to work.

3.4.2 Switching the device off

On switch-off, the last input condition and the most recent set values and input status are saved. Furthermore, a PF alarm (power failure) will be reported, but has to be ignored here.

The DC input is immediately switched off and after a short while the device will be completely powered off.

3.4.3 Configuration via MENU

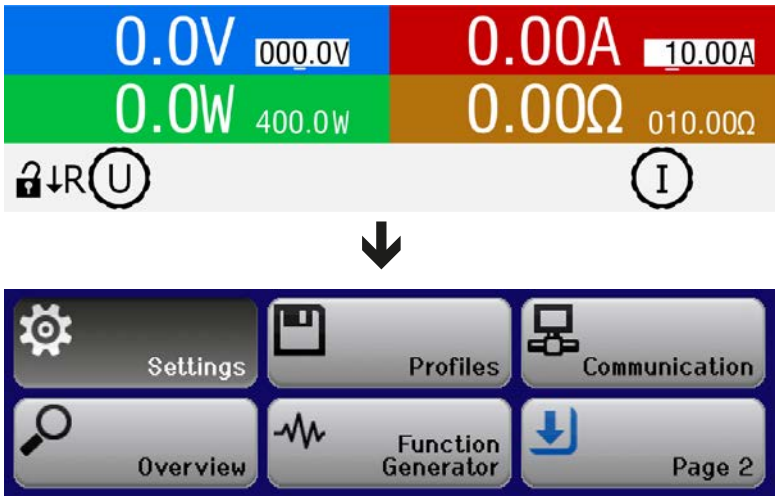
The MENU serves to configure all operating parameters which are not constantly required. These can be set by pressing button MENU, but only if the DC input is switched OFF. See figures below.

If the DC input is switched on the settings menu will not be shown, only status information.

Menu navigation is by using the arrow buttons, as well as Enter and ESC. Values and parameters are set using the rotary knobs. The assignment of the knobs to the adjustable values isn't indicated in menu pages, but following applies:

- Values on the left side of the screen -> left-hand knob
- value on the right side of the screen -> right-hand knob.
- multiple values on any side -> switching to the next is done with the arrow buttons

Some setting parameters are self-explanatory, others are not. Those will be explained on the next pages.



3.4.3.1 Menu “Settings”

This is main menu for all settings related to the general operation of the device and of the interface(s).

Sub menu	Description
Input Settings	Allows for adjustment of set values related to the DC input, alternatively to the handling in the main screen of the display
Protection Settings	Allows for adjustment of protection thresholds (here: OVP, OCP, OPP) related to the DC input. Also see section *„3.3. Alarm conditions“*
Limit Settings	Allows for adjustment of adjustment limits for set values. Also see section *„3.4.4. Adjustment limits“*
General Settings	Settings for the operation of the device and its interface(s). Details below
Reset Device	When selecting **Yes** and confirming with **Enter** button, it will initiate a reset of all settings (HMI, profile etc.) to factory default, as shown in the menu structure diagrams on the previous pages

3.4.3.2 Menu “General Settings”

Setting	Description
Allow remote control	Selection **NO** means that the device can’t be remotely controlled over either the digital or analog interfaces. If remote control isn’t allowed, the status will be shown as **Local** in the status area on the main display. Also see section *1.9.5.1.*
DC input after Power ON	Determines the condition of the DC input after power-up. • **OFF** = DC input is always off after switching on the device. • **Restore** = DC input condition will be restored to the condition prior to switch off.
DC input after PF alarm	Determines how the DC input shall react after a power fail (PF) alarm has occurred: • **OFF** = DC input will be switched off and remain until user action • **AUTO** = DC input will switch on again after the PF alarm cause is gone and if it was switched on before the alarm occurred
DC input after remote	Determines the condition of the DC input after leaving remote control either manually or by command. • **OFF** = DC input will be always off when switching from remote to manual • **AUTO** = DC input will keep the last condition
Voltage controller setting	Selects the regulation speed of the internal voltage regulator between **Slow** and **Fast**. See *„3.2.1.1. Speed of the voltage controller“.*
Enable R mode	Activates (**Yes**) or deactivates (**No**) the internal resistance control. If activated, the resistance set value can be adjusted on the main screen as additional value. For details refer to *„3.2.3. Resistance regulation / constant resistance“.*
Analog Rem-SB action	*This parameter is only displayed if the optional Analog/USB interface is installed.* Selects the action on the DC input that is initiated when changing the level of analog input REM-SB: • **DC OFF** = the pin can only be used to switch the DC input off • **DC ON/OFF** = the pin can be used to switch the DC input off and on again, if it has been switched on before at least from a different control location
Analog interface range	*This parameter is only displayed if the optional Analog/USB interface is installed.* Selects the voltage range for the analog set values, monitoring outputs and reference voltage output. • **0...5 V** = Range is 0...100% set /actual values, reference voltage 5 V • **0...10 V** = Range is 0...100% set /actual values, reference voltage 10 V See also section *„3.5.4. Remote control via the analog interface (AI)“*

Setting	Description
Analog interface Rem-SB	*This parameter is only displayed if the optional Analog/USB interface is installed.* Selects how the input pin REM-SB of the analog interface shall be working regarding levels and logic: • **Normal** = Levels and function as described in the table in *3.5.4.4* • **Inverted** = Levels and function will be inverted Also see *„3.5.4.7. Application examples“*

3.4.3.3 Menu “Profiles”

See *„3.8 Loading and saving an user profile“ on page 42.*

3.4.3.4 Menu “Overview”

This menu page displays an overview of the set values (U, I, P or U, I, P, R) and alarm settings as well as adjustment limits. These can only be displayed, not changed.

3.4.3.5 Menu “About HW, SW...”

This menu page displays an overview of device relevant data such as serial number, article number etc., as well as an alarm history which lists the number of device alarms that probably occurred since the device has been powered.

3.4.3.6 Menu “Function Generator”

See *„3.9 The function generator“ on page 43.*

3.4.3.7 Menu “Communication”

All settings for the optional, digital interface which can be installed on the rear side, are configured here. The USB port, as included with all three optional interface cards doesn’t require configuration. When installing interface type IF-KE5 USB LAN the device features an Ethernet/LAN port. After installation or a complete device reset, that Ethernet port has following **default settings** assigned:

- DHCP: off
- IP: 192.168.0.2
- Subnet mask: 255.255.255.0
- Gateway: 192.168.0.1
- Port: 5025
- DNS: 0.0.0.0
- Host name: “Client”, but configurable via PC software
- Domain: “Workgroup”, but configurable via PC software

Those settings can be changed anytime and configured to meet local requirements. Furthermore, there are global communication settings available regarding timing and protocols.

Sub menu **IP Settings 1**

Element	Description
Get IP address	**DHCP**: With setting DHCP the device will instantly try to get network parameters (IP, subnet mask, gateway, DNS) assigned from a DHCP server after power-on or when changing from **Manual** to **DHCP** and submitting the change with button ENTER. If the DHCP configuration attempt fails, the device will use the settings from **Manual**. In this case, the overview in screen **View Settings** will indicate the DCHP status as **DHCP (failed)**, otherwise as **DHCP(active)** **Manual** (default setting): uses either the default network parameters (after reset) or the last user setting. Those parameters are not overwritten from selection **DHCP** and are thus available when switching to **Manual** again.
IP address	Only available with setting **Manual**. Default value: 192.168.0.2 Manual setting of the device’s IP address in standard IP format (setting will be stored)
Subnet mask	Only available with setting **Manual**. Default value: 255.255.255.0 Manual setting of the subnet mask in standard IP format (setting will be stored)
Gateway	Only available with setting **Manual**. Default value: 192.168.0.1 Manual setting of the gateway address in standard IP format (setting will be stored)

Sub menu **Ethernet**

Element	Description
Port	Default value: **5025** Adjust the socket port here, which belongs to the IP address and serves for TCP/P access when controlling the device remotely via Ethernet
DNS address	Default value: **0.0.0.0** Permanent manual setting of the network address of a domain name server (short: DNS) which has to be present in order to translate the host name to the device's IP, so the device could alternatively access by the host name
Enable TCP Keep-Alive	Default setting: disabled Enables/disables the so-called keep-alive functionality of TCP.

Sub menu **Communication Protocols**

Element	Description
Enabled	Default setting: **SCPI&ModBus** Enables/disables SCPI or ModBus RTU communication protocols for the device. The change is immediately effective after submitting it with ENTER button. Only one of both can be disabled.

Sub menu **Communication Timeout**

Element	Description
Timeout USB (ms)	Default value: **5**, Range: 5...65535 USB/RS232 communication timeout in milliseconds. Defines the max. time between two subsequent bytes or blocks of a transferred message. For more information about the time-out refer to the external programming documentation "Programming Guide ModBus & SCPI".
Timeout ETH (s)	Default value: **5**, Range: 5...65535 If there was no communication between the controlling unit (PC, PLC etc.) and the device for the adjusted time, it will close the socket connection. This time-out will be ineffective as long as the option **Enable TCP keep-alive** (see above) is activated and "keep-alive" is working as expected within the network.

3.4.3.8 Menu "HMI settings"

These settings refer exclusively to the control panel (HMI).

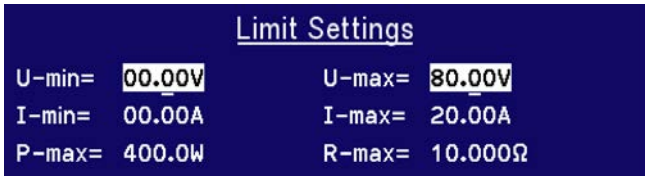
Element	Description
Language	Selection of the display language between German, English, Russian or Chinese. Default setting: **English**
Backlight Setup	The choice here is whether the backlight remains permanently on or if it should be switched off when no input via push buttons or rotary knob is done for 60 s. As soon as input is done, the backlight returns automatically. Furthermore the backlight intensity can be adjusted here. Default settings: **100**, **Always on**
Status page	Switches to a different main screen layout. The user can select between two layouts which are depicted by small graphics as a preview. Also see section *„3.4.6. Switching the main screen view"*. Default setting: **Layout 1**
Key Sound	Activates or deactivates sounds when pressing a button on the HMI. It can usefully signal that the action has been accepted. Default setting: **off**
Alarm Sound	Activates or deactivates the additional acoustic signal of an alarm or user defined event which has been set to **Action = ALARM**. See also *„3.6 Alarms and monitoring" on page 40.* Default setting: **off**
HMI Lock	See *„3.7 Control panel (HMI) lock" on page 41.* Default settings: **Lock all**, **No**

3.4.4 Adjustment limits

Adjustment limits are only effective on the related set values, no matter if using manual adjustment or remote control!

Defaults are, that all set values (U, I, P, R) are adjustable from 0 to 102%.

This may be obstructive in some cases, especially for protection of applications against overcurrent. Therefore upper and lower limits for current (I) and voltage (U) can be set which limit the range of the adjustable set values.



For power (P) and resistance (R) only upper value limits can be set.

► How to configure the adjustment limits

1. While the DC input is switched off, press button Menu.
2. In the menu press Enter, then navigate to **Limit Settings** with the arrow buttons (↓, ↑) and press Enter again.
3. In each case a pair of upper and lower limit for U/I or the upper limit for P/R are assigned to the rotary knobs and can be adjusted. In order to switch to a different pair, press the arrow buttons.
4. Accept the settings with Enter.

The adjustment limits are coupled to the set values. It means, that the upper limit may not be set lower than the corresponding set value. Example: If you wish to set the upper limit for the current (I-max) to 35 A while the set value of currently is adjusted to 40 A, then the set value of current would first have to be reduced to 35 A or less in order to enable setting I-max down to 35 A.

3.4.5 Manual adjustment of set values

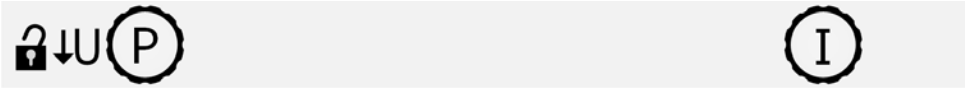
The set values for voltage, current, power and resistance are the fundamental operating possibilities of an electronic load and hence the two rotary knobs on the front of the device are always assigned to two of the four values in manual operation. Default assignment is voltage and current. The set values can only be adjusted with the rotary knobs.

Using the knobs to adjust a value in the main screen changes it immediately and no matter if the DC input is switched on or off. This is different to set value adjustment in the menu, where you have to press the "Enter" button to submit changes.

When adjusting set values, upper or lower limits may come into effect. See section „3.4.4. Adjustment limits". Once a limit is reached, the main screen will show a note like "Limit: U-max" etc. for 1.5 seconds in the status area, while in the menu this is reduced to an exclamation mark.

► How to adjust values with the rotary knobs

1. First check if the value you want to change is already assigned to one of the rotary knobs. The main screen displays the assignment like this:



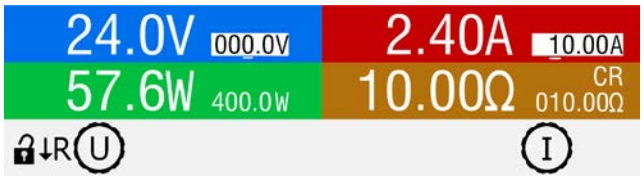
2. If, as shown above, the assignment is power (**P,** left) and current (**I**, right), and it's required to set the voltage, then the assignment of the left-hand knob can be changed by pressing the arrow down button (↓).
3. After successful selection, the desired value can be set within the defined limits. Selecting a digit is done by pushing the rotary knob which shifts the cursor from right to left (selected digit will be underlined):

3.4.6 Switching the main screen view

The main screen, also called status page, with its set values, actual values and device status can be switched from the standard view mode with three or four values to a simpler mode which only shows two physical values.

The advantage of the alternative view mode is that actual values are displayed with **bigger numbers**, so they read be read from a larger distance. Refer to *„3.4.3.8. Menu "HMI settings""* to see where to switch the view mode in the MENU. Comparison:

Layout 1 (standard)



Layout 2 (alternative)

Differences of layout 2:

- The two hidden physical values are shown when switching the knob assignment, which also changes the upper left half of the display
- The actual regulation mode is displayed no matter what pair of physical values is currently shown, in the lower left corner, as the example in the upper figure on the right side depicts with **CR**; this is the equivalent of layout 1

3.4.7 Switching the DC input on or off

The DC input of the device can be manually or remotely switched on and off. This can be restricted in manual operation by the control panel being locked.

	Switching the DC input on during manual operation or digital remote control can be disabled by pin REM-SB of the optional analog interface, if installed and if the corresponding parameter is activated. For more information refer to 3.4.3.2 and example a) in 3.5.4.7. In such a situation, the device would show a notification in the display.

► How to manually switch the DC input on or off

1. As long as the control panel (HMI) isn't fully locked press the button On / Off. Otherwise you are asked to disable the HMI lock, either by simply pressing Enter or entering the PIN, if the PIN has been activated in menu **HMI Lock**.
2. The ON/OFF button toggles between on and off, as long as a change isn't restricted by any alarm or the device being in remote control. The DC input condition is indicated by the two LEDs (green = on, red = off) on the On / Off button.

► How to remotely switch the DC input on or off via the analog interface

1. See section *„3.5.4 Remote control via the analog interface (AI)" on page 36.*

► How to remotely switch the DC input on or off via the digital interface

1. See the external documentation "Programming Guide ModBus & SCPI" if you are using custom software, or refer to the external documentation of LabView VIs or other documentation provided by EA Elektro-Automatik.

3.5 Remote control

3.5.1 General

Remote control is possible via any of the optionally available, user-retrofittable interface cards (refer to *„1.9.4. Optional accessories“*) and their feature analog or digital interface port. Important here is that only one of both ports can be in control. It means that if, for example, an attempt were to be made to switch to remote control via the digital interface whilst analog remote control is active (pin REMOTE = LOW) the device would report an error via the digital interface. In the opposite direction, a switch-over via pin REMOTE would be ignored. In both cases, however, status monitoring and reading of values are always possible.

3.5.2 Controls locations

Control locations are those locations from where the device is control. Essentially there are two: at the device (manual control) and external (remote control). The following locations are defined:

Displayed location	Description
-	If neither of the other locations is displayed then manual control is active and access from the analog and digital interfaces is allowed. This location isn't explicitly displayed
Remote	Remote control via any interface is active
Local	Remote control is locked, only manual operation is allowed.

Remote control can be explicitly allowed or inhibited using the setting **Allow remote control** (see *“„3.4.3.2. Menu “General Settings”“*). In inhibited condition, the status **Local** will be shown in the status area of the display. Activating the lock can be useful if the device is remotely controlled by software or some electronic device, but it's required to make adjustments at the device or deal with emergency situations, which would not be possible remotely.

Activating condition **Local** causes the following:

- If remote control via the digital interface is active (shown as **Remote:**), then it's immediately terminated and in order to continue remote control once **Local** is no longer active, it has to be reactivated from the PC side
- If remote control via the analog interface is active (**Remote: Analog**), then it's temporarily interrupted until remote control is allowed again by deactivating **Local**, because pin REMOTE continues to signal “remote control = on”, unless the signal has been changed during the **Local** period.

3.5.3 Remote control via a digital interface

3.5.3.1 Selecting an interface

The device only supports the optionally available, digital interfaces USB and Ethernet.

For USB, a standard USB cable is included in the delivery of the interface card, not with the device, as well as a driver for Windows on USB stick. The USB interface requires no setup in the MENU.

The Ethernet interface typically requires network setup (manual or DHCP), but can also be used with its default parameters right from the start.

3.5.3.2 General

For the network port installation refer to *„1.9.7. Ethernet port (optional)“.*

The digital interface require little or no setup for operation and can be directly used with their default configuration. All specific settings will be permanently stored, but could also be reset to defaults with the setup menu item **Reset Device**.

Via the digital interface primarily the set values (voltage, current, power) and device conditions can be set and monitored. Furthermore, various other functions are supported as described in separate programming documentation.

Changing to remote control will retain the last set values for the device until these are changed. Thus a simple voltage control by setting a target value is possible without changing any other values.

3.5.3.3 Programming

Programming details for the interfaces, the communication protocols etc. are to be found in the documentation “Programming Guide ModBus & SCPI“ which is supplied on the included USB stick or which is available as download from the EA Elektro-Automatik website.

3.5.4 Remote control via the analog interface (AI)

3.5.4.1 General

The optionally available, galvanically isolated, 15-pole analog interface (short: AI) is located on the rear side of the device and offers the following possibilities:

- Remote control of current, voltage, power and resistance
- Remote status monitoring (CC/CP, CV)
- Remote alarm monitoring (OT, OVP, PF)
- Remote monitoring of actual values
- Remote on/off switching of the DC input

Setting the set values of voltage, current and power via the analog interface must always be done concurrently. It means, that for example the voltage can't be given via the AI and current and power set by the rotary knobs, or vice versa. Using the resistance mode and can be switched on or off, so this signal isn't always required.

Any device protection thresholds, such as OVP, can't be set via the AI and therefore must be adapted to the given situation before the AI takes over control. Analog set values can be supplied by an external voltage source or generated from the reference voltage on pin 3. As soon as remote control via the analog interface is activated, the display will show the set values as provided on the analog interface.

The AI can be operated in the common voltage ranges 0...5 V and 0...10 V, both representing 0...100% of the nominal value. The selection of the voltage range can be done in the device setup. See section *„3.4.3. Configuration via MENU“* for details. The reference voltage sent out from pin 3 (VREF) will be adapted accordingly:

0-5 V: Reference voltage = 5 V, 0...5 V set value signal for VSEL, CSEL and PSEL correspond to 0...100% nominal value while for RSEL it's R_{MIN}...R_{MAX}, 0...100% actual values correspond to 0...5 V at the actual value outputs CMON and VMON.

0-10 V: Reference voltage = 10 V, 0...10 V set value signal for VSEL, CSEL and PSEL correspond to 0...100% nominal value while for RSEL it's R_{MIN}...R_{MAX}, 0...100% actual values correspond to 0...10 V at the actual value outputs CMON and VMON.

All set values are always additionally limited to the corresponding adjustment limits (U-max, I-max etc.), which would clip setting excess values for the DC output. Also see section *„3.4.4. Adjustment limits“*.

Before you begin, please read these important notes for use of the interface:

	*After powering the device and during the start phase the AI signals undefined statuses on the output pins such as ALARMS or OVP. Those must be ignored until is ready to work.*

- Analog remote control of the device must be activated by switching pin REMOTE first. Only exception is pin REM-SB, which can be used independently
- Before the hardware is connected that will control the analog interface, it shall be checked that it can't provide voltage to the pins higher than specified
- Set value inputs, such as VSEL, CSEL, PSEL and RSEL (if R mode is activated), must not be left unconnected (i.e. floating) during analog remote control. In case any of these isn't used for adjustment, it should be tied to a defined level like ground or connected to pin VREF (solder bridge or different), so it gives 100%

3.5.4.2 Resolution

The analog interface is internally sampled and processed by a digital microcontroller. This causes a specific effective resolution, i. e. analog steps. The resolution is the same for set values (VSEL etc.) and actual values (VMON/CMON) and is 4096 when working with the 10 V range. In the 5 V range this resolution halves. Due to tolerances, the truly achievable resolution can be slightly lower.

3.5.4.3 Acknowledging device alarms

Device alarms (see *3.6.1*) are always indicated in the front display and some of them are also reported as signal on the analog interface socket (see table below).

In case of a device alarm occurring during remote control via analog interface, the DC input will be switched off the same way as in manual control. While alarms like OT (overtemperature), PF (power fail) and OV (overvoltage) can be monitored via the corresponding pins of the interface, other alarms like overcurrent (OC) can't. Those could only be detected via the actual values of voltage and current being all zero contrary to the set values.

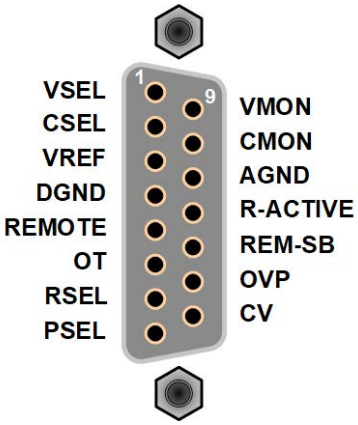
Some device alarms (OV, OC and OP) have to be acknowledged, either by the user of the device or by the controlling unit. Also see *„3.6.1. Device alarm and event handling".* Acknowledgement is done with pin REM-SB switching the DC input off and on again, means a HIGH-LOW-HIGH edge (at least 50 ms for LOW).

3.5.4.4 Analog interface specification

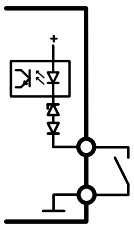
Pin	Name	Type*	Description	Default levels	Electrical specification
1	VSEL	AI	Set voltage value	0…10 V or. 0...5 V correspond to 0..100% of U_{Nom}	Accuracy 0-5 V range: < 0.4% ***** Accuracy 0-10 V range: < 0.2% ***** Input impedance R_i >40 k...100 k
2	CSEL	AI	Set current value	0…10 V or. 0...5 V correspond to 0..100% of I_{Nom}	
3	VREF	AO	Reference voltage	10 V or 5 V	Tolerance < 0.2% at I_{max} = +5 mA Short-circuit-proof against AGND
4	DGND	POT	Ground for all digital signals		For control and status signals
5	REMOTE	DI	Switching manual / remote control	Remote = LOW, U_{Low} <1 V Manual = HIGH, U_{High} >4 V Manual, if not connected	Voltage range = 0…30 V I_{Max} = -1 mA at 5 V $U_{LOW\ to\ HIGH\ typ.}$ = 3 V Rec'd sender: Open collector against DGND
6	ALARMS	DO	Overheating alarm Power fail alarm ***	Alarm = HIGH, U_{High} > 4 V No alarm = LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc ** With 5 V on the pin max. flow +1 mA I_{Max} = -10 mA at U_{CE} = 0,3 V U_{Max} = 30 V Short-circuit-proof against DGND
7	RSEL	AI	Set internal resistance value	0…10 V or. 0...5 V correspond to 0..100% of R_{Max}	Accuracy 0-5 V range: < 0.4% ***** Accuracy 0-10 V range: < 0.2% ***** Input impedance R_i >40 k...100 k
8	PSEL	AI	Set power value	0…10 V or. 0...5 V correspond to 0..100% of P_{Nom}	
9	VMON	AO	Actual voltage	0…10 V or. 0...5 V correspond to 0..100% of U_{Nom}	Accuracy 0-5 V range: < 0.4% ***** Accuracy 0-10 V range: < 0.2% ***** at I_{Max} = +2 mA Short-circuit-proof against AGND
10	CMON	AO	Actual current	0…10 V or. 0...5 V correspond to 0..100% of I_{Nom}	
11	AGND	POT	Ground for all analog signals		For -SEL, -MON, VREF signals
12	R-ACTIVE	DI	R mode on / off	Off = LOW, U_{Low} <1 V On = HIGH, U_{High} >4 V On, if not connected	Voltage range = 0…30 V I_{Max} = -1 mA at 5 V $U_{LOW\ to\ HIGH\ typ.}$ = 3 V Rec'd sender: Open collector against DGND
13	REM-SB	DI	DC input OFF (DC input ON) (ACK alarms ****)	Off = LOW, U_{Low} <1 V On = HIGH, U_{High} >4 V On, if not connected	Voltage range = 0…30 V I_{Max} = +1 mA at 5 V Rec'd sender: Open collector against DGND
14	OVP	DO	Overvoltage alarm	Alarm = HIGH, U_{High} > 4 V No alarm = LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc ** With 5 V on the pin max. flow +1 mA I_{Max} = -10 mA at U_{CE} = 0,3 V, U_{Max} = 30 V Short-circuit-proof against DGND
15	CV	DO	Constant voltage regulation active	CV = LOW, U_{Low} <1 V CC/CP/CR = HIGH, U_{High} >4 V	

* AI = Analog Input, AO = Analog Output, DI = Digital Input, DO = Digital Output, POT = Potential
** Internal Vcc approx. 10 V
*** AC supply blackout or PFC failure or supply undervoltage
**** Only during remote control
***** The error of a set value input adds to the general error of the related value on the DC input of the device

3.5.4.5 Overview of the Sub-D Socket

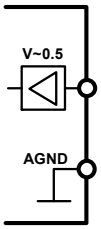


3.5.4.6 Simplified diagram of the pins



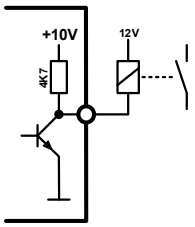
Digital Input (DI)

It requires to use a switch with low resistance (relay, switch, circuit breaker etc.) in order to send a clean signal to the DGND.



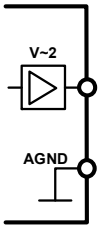
Analog Input (AI)

High resistance input (impedance >40 k....100 kΩ) for an operational amplifier circuit.



Digital Output (DO)

A quasi open collector, realised as high resistance pull-up against the internal supply. In condition LOW it can carry no load, merely switch, as shown in the diagram with a relay as example.

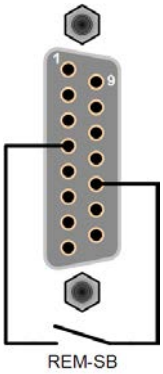


Analog Output (AO)

Output from an operational amplifier circuit, with low impedance. See specifications table above.

3.5.4.7 Application examples

a) Switching the DC input off or on via the pin REM-SB



A digital output, e.g. from a PLC, may be unable to cleanly effect this as it may not be of low enough resistance. Check the specification of the controlling application. Also see pin diagrams above.

In remote control, pin REM-SB is used to switch the DC input of the device on and off. This is also available without remote control being active.

It is recommended that a low resistance contact such as a switch, relay or transistor is used to switch the pin to ground (DGND).

Following situations can occur:

- **Remote control has been activated**

During remote control via analog interface, only pin REM-SB determines the states of the DC input, according to the levels definitions in *3.5.4.4*. The logical function and the default levels can be inverted by a parameter in the setup menu of the device. See *3.4.3.2*.

If the pin is unconnected or the connected contact is open, the pin will be HIGH. With parameter "Analog interface REM-SB" being set to "Normal", it requests "DC input on". In this situation, when activating remote control, the DC input would instantly switch on.

- **Remote control isn't active**

In this mode of operation pin REM-SB can serve as lock, preventing the DC input from being switched on by any means. This results in following possible situations:

DC-input	+	Level on pin „REM-SB“	+	Parameter „Analog interface REM-SB“	➔	Behaviour
is off	+	HIGH	+	**Normal**	➔	DC input not locked. It can be switched on by pushbutton On/Off (front panel) or via command from digital interface.
		LOW	+	**Inverted**		
	+	HIGH	+	**Inverted**	➔	DC input locked. It can't be switched on by pushbutton On/Off (front panel) or via command from digital interface. When trying to switch on, a popup in the display resp. an error message will be generated.
		LOW	+	**Normal**		

In case the DC input is already switched on, toggling the pin will switch the DC input off, similar to what it does in analog remote control:

DC-input	➔	Level on pin „REM-SB“	+	Parameter „Analog interface REM-SB“	➔	Behaviour
is on	➔	HIGH	+	**Normal**	➔	DC input remains on, nothing is locked. It can be switched on or off by pushbutton or digital command.
		LOW	+	**Inverted**		
	➔	HIGH	+	**Inverted**	➔	DC input will be switched off and locked. Later it can be switched on again by toggling the pin. During lock, pushbutton or digital command can delete the request to switch on by pin.
		LOW	+	**Normal**		

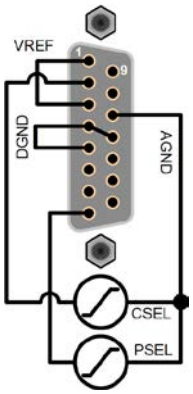
b) Remote control of current and power.

Requires remote control to be activated (Pin REMOTE = LOW)

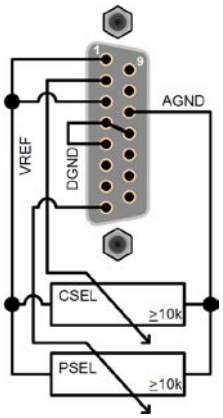
The set values PSEL and CSEL are generated from, for example, the reference voltage VREF, using potentiometers for each. Hence the electronic load can selectively work in current limiting or power limiting mode. According to the specification of max. 5 mA load for the VREF output, potentiometers of at least 10 kΩ must be used.

The voltage set value VSEL is directly connected to AGND (ground) and therefore has no influence on constant current or power operation.

If the control voltage is fed in from an external source it's necessary to consider the input voltage ranges for set values (0...5 V or 0...10 V).



Example with external voltage source

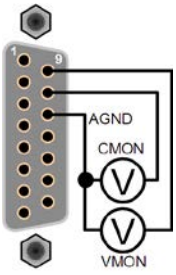


Example with potentiometers

Use of the input voltage range 0...5 V for 0...100% set value halves the effective resolution.

c) Reading actual values

The AI provides the DC input values as current and voltage monitor. These can be read using a standard multimeter or similar.



3.6 Alarms and monitoring

3.6.1 Device alarm and event handling

Important to know:

- The current drained from a switching power supply or similar sources can be much higher than expected due to capacities on the source's output, even if the source is current limited, and might thus trigger the overcurrent shutdown OCP of the electronic load, in case its threshold is adjusted too sensitively, it means too close to the related current set value
- When switching off the DC input of the electronic load while a current limited source still supplies energy, the output voltage of the source will rise immediately and due to response and settling times in effect, the output voltage can have an overshoot of unknown level which might trigger the overvoltage shutdown OVP, in case its threshold is adjusted too sensitively, it means too close to the related voltage set value

A device alarm incident will usually lead to DC input switch-off, the appearance of a text message in the display and, if activated, an acoustic signal to make the user aware. The alarm must always be acknowledged. If the alarm condition no longer exists, e.g. the device has cooled down following overheating, the alarm indication may have disappeared already. If the condition persists, the display remains and the alarm can only be acknowledged after elimination of the cause.

► How to acknowledge an alarm in the display (during manual control)

1. Once an alarm is indicated, the user can try to acknowledge and delete the alarm by pressing either button Enter or On / Off.

In order to acknowledge an alarm during analog remote control, see *„3.5.4.3. Acknowledging device alarms“*. To acknowledge in digital remote, refer to the external documentation "Programming ModBus RTU & SCPI".

Some device alarms are configurable:

Alarm	Meaning	Description	Range	Indication
OVP	**O**ver**V**oltage **P**rotection	Triggers an alarm as soon as the DC input voltage reaches the defined threshold. The DC input will be switched off.	0 V...1.03*U_{Nom}	Display, analog & digital interface
OCP	**O**ver**C**urrent **P**rotection	Triggers an alarm as soon as the DC input current reaches the defined threshold. The DC input will be switched off.	0 A....1.1*I_{Nom}	Display, digital interface
OPP	**O**ver**P**ower **P**rotection	Triggers an alarm as soon as the DC input power reaches the defined threshold, The DC input will be switched off.	0 W...1.1*P_{Nom}	Display, digital interface

These device alarms can't be configured and are based on hardware:

Alarm	Meaning	Description	Indication
PF	**P**ower **F**ail	AC supply over- or undervoltage. Triggers an alarm if the AC supply is out of specification or when the device is cut from supply, for example when switching it off with the power switch. The DC input will be switched off which could be only temporarily, depending on the situation and setting **DC input after PF alarm** (see *3.4.3.1*).	Display, analog & digital interface
OT	**O**ver**Tem-perature**	Triggers an alarm if the internal temperature exceeds a certain limit. The DC input will be switched off.	Display, analog & digital interface

► **How to configure the device alarms**

2. While the DC input is switched off, press button Menu.
3. In the menu press Enter, then navigate to **Protection Settings** with the arrow buttons (↓, ↑) and press Enter again.
4. Set the thresholds for the device alarms relevant to your application if the default value of 103% (OVP) resp. 110% (OCP, OPP) is unsuitable.

The user also has the possibility of selecting whether an additional acoustic signal will be sounded if an alarm or user defined event occurs.

► **How to configure the alarm sound** (also see **"***„3.4.3. Configuration via MENU"*)

5. While the DC input is switched off, press button Menu.
6. In the menu navigate with the arrow buttons (↓, ↑) to **Page 2** and press Enter. In the following menu page, navigate to **HMI Settings** and press Enter again.
7. There navigate to **Alarm Sound** and reach the settings page by pressing Enter once more.
8. In the settings page select **On** or **Off** and confirm with Enter.

3.7 Control panel (HMI) lock

In order to avoid the accidental alteration of a value during manual operation, the rotary knobs or the buttons can be locked so that no alteration of values will be accepted without prior unlocking.

► **How to lock the HMI**

1. While the DC input is switched off, press button Menu
2. In the menu use the arrow buttons (↓, ↑) to navigate to **Page 2**, then press Enter. In the next menu page navigate to **HMI Setup** and press Enter again.
3. In there navigate to **HMI Lock** to access the settings page with Enter.
4. The simple (default) HMI lock is activated by pressing Enter here, which will immediately leave the menu and jump back to the main screen. The active lock is indicated by text **Locked** and symbol  .

Alternatively to the simple lock, which can be unlocked very easily by every person and thus offers no protection against intentional misuse, a PIN can set up and activated, which then is requested to be entered every time the HMI is going to be unlocked.

► **How to lock the HMI with PIN**

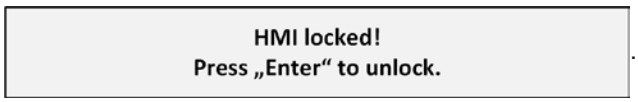
Don't activate the PIN lock if you are unsure about the current PIN! It can be changed, but only if the current PIN is entered.

5. Select parameter to **Enable PIN** and set the parameter to **Yes** with the right-hand knob.
6. In order to change the PIN prior to activation select **Change PIN** and press Enter to access the next screen where you are requested to enter the former PIN once and the new PIN twice and confirm every step with Enter.
7. Back in the previous activate the PIN lock with Enter, which will immediately leave the menu and jump back to the main screen. The active lock is indicated by text **Locked** and symbol  .

If an attempt is made to alter something whilst the HMI is locked, a requester appears in the display asking if the lock should be disabled.

► How to unlock the HMI

1. Turn one of the rotary knobs or press any button (except for On/Off when lock mode **ON/OFF possible** has been set).
2. This request pop-up will appear:



3. Unlock the HMI by pressing Enter within 5 seconds, otherwise the pop-up will disappear and the HMI remains locked. In case the additional PIN code lock has been activated in the menu **HMI Lock**, another requester will pop up, asking you to enter the PIN before it finally unlocks the HMI.

3.8 Loading and saving an user profile

The menu **Profiles** serves to select between a default profile and up to 5 user profiles. A profile is a collection of all settings and set values. Upon delivery, or after a reset, all 6 profiles have the same settings and all set values are 0. If the user changes settings or sets target values then these create a working profile which can be saved to one of the 5 user profiles. These profiles or the default one can then be switched. The default profile is read-only.

The purpose of a profile is to load a set of set values, settings limits and monitoring thresholds quickly without having to readjust these. As all HMI settings are saved in the profile, including language, a profile change can also be accompanied by a change in HMI language.

On calling up the menu page and selecting a profile the most important settings can be seen, but not changed.

► How to save the current values and settings as an user profile

1. While the DC input is switched off, press button Menu
2. In the menu use the arrow buttons (↓, ↑) to navigate to **Profiles**, then press Enter.
3. In the selection screen select one of the **User Profile 1-5** entries by using the arrow buttons and confirm with Enter.
4. In the sub menu select **Save settings into Profile x** and confirm with Enter.

Loading a profile is done the same way.

3.9 The function generator

3.9.1 Introduction

The built-in **function generator** is able to create various signal forms and apply these to the set value of voltage or current.

The functions are based on an **ramp generator** and directly accessible and configurable using manual control. For remote control, the desired function run can be configured using several setup parameters. The functions “Battery test” and “MPP tracking” are not based on this generator.

The following functions are retrievable, configurable and controllable:

Function	Short description
Triangle	Triangular wave signal generation with adjustable amplitude, offset, rise and fall times
Rectangular	Rectangular wave signal generation with adjustable amplitude, offset and pulse/pause time
Trapezoid	Trapezoidal wave signal generation with adjustable amplitude, offset, rise time, pulse time, fall time, idle time
Ramp	Generation of a linear rise or fall ramp with start value, end value and rise/fall time
Battery test	Battery discharge test with constant or pulsed current, along with Ah, Wh and time counters
MPP Tracking	Simulation of the characteristic tracking behaviour of solar inverters when seeking to find the maximum power point (MPP) when being connected to typical sources such as solar panels

3.9.2 General

3.9.2.1 Resolution

Amplitudes generated by the arbitrary generator have an effective resolution of approx. 3277 steps. If the amplitude is very low and the time long, the device would generate less steps and set multiple identical values after another, generating a staircase effect. It is furthermore not possible to generate every possible combination of time and a varying amplitude (slope).

3.9.3 Method of operation

In order to understand how the function generator works and how the value settings interact, the following should be noted:

The device operates always with the three set values U,I and P, also in function generator mode.

The selected function can be used on one of the values U or I, the other two are then constants and have a limiting effect. That means, if, e.g. a voltage of 10 V is applied to the DC input and a rectangle function should operate on the current with an amplitude of 20 A and offset 20 A, then the function generator will create a rectangular wave progression of current between 0 A (min) and 40 A (max), which will result in an input power between 0 W (min) and 400 W (max).The input power, however, is limited to its set value. If this were 300 W then, in this case, the current would be limited to 30 A and, if clamped to an oscilloscope, it would be seen to be capped at 30 A and never achieve the target of 40 A.

Another case is when working with a function which is applied to the input voltage. If here the static voltage is set higher than the amplitude plus offset then at function start there will be no reaction, as the voltage regulation limits down to 0 with an electronic load, other than current or power. The correct settings for each of the other set values is therefore essential.

3.9.4 Manual operation

3.9.4.1 Function selection and control

Via the touchscreen one of the functions listed in *3.9.1* can be called up, configured and controlled. Selection and configuration are only possible when the input is switched off.

► How to select a function and adjust parameters

1. While the DC input is switched off, press button Menu.
2. In the menu navigate to “**Function Generator”** with the arrow buttons (↓, ↑) and press Enter again.

3. In the next menu screen select the desired function with Enter. Depending on the choice of function there follows a request to which value the function generator is going to be applied: U Voltage or I Current.

4. Adjust the parameters as you desire, like start level, end level and rise time for a rising ramp, for example. The parameters of the various functions are described below. Switching between the different parameters on screen is done with the arrow buttons.

5. Submit with Enter to enter the next screen. Here adjust the overall limits of voltage, current and power in the following.

> *When entering function generator mode, those global limits are reset to safe values, which might prevent the function from working at all. For example, if you apply the selected function to the input current, then the overall current limit should not interfere and should at least be as high as offset + amplitude.*

> *Because the DC input is automatically switched on in order to settle the start situation, the static values are effective to the source immediately after loading the function. These static values represent the situation before start and after the end of the function, so it doesn't need to start from 0. Only exception: when applying any function to the current (I), there is no adjustable static current value, so the function would always start from 0 A.*

6. Press Enter once more to load the function and to enter function generator screen.

Shortly afterwards the static values are set (power and voltage or current), the DC input is switched on. Then can the function be started.

► How to start and stop a function

1. The function can be **started** either by pushing button Enter or, if the DC input is currently switched of, by pushing button On / Off.

2. The function can be **stopped** either by pushing button Enter or button On / Off. There is different behaviour:

   a) The Enter button only stops the function, the DC input remains ON with the static values in effect.

   b) The On / Off button stops the function and switches the DC input off.

> *Any device alarm (overvoltage, overtemperature etc.) stops the function progress automatically, switches off the DC input and reports the alarm.*

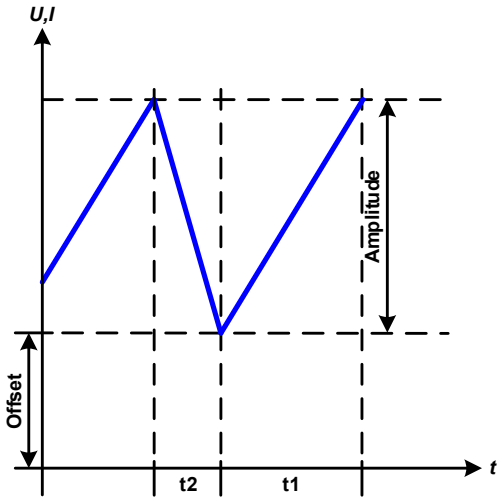
3.9.5 Triangular function

The following parameters can be configured for a triangular wave function:

Value	Range	Description
Ampl.	0...(Rated value - Offset)) of U or I	Ampl. = Amplitude of the signal to be generated
Offset	0...(Rated value - Ampl) of U or I	Offset, based on the foot of the triangular wave
t1	0.01 ms...6000 s	Time for the positive slope of the triangular wave signal.
t2	0.01 ms...6000 s	Time for the negative slope of the triangular wave signal

When adjusting very short time value for t1 and t2 not every adjustable amplitude can be gained on the DC input. Rule of thumb: the smaller the time value, the lower the true amplitude.

Schematic diagram:



Application and result:

A triangular wave signal for input current or input voltage is generated. The positive and negative slope times are variable and can be set independently.

The offset shifts the signal on the Y-axis.

The sum of the intervals t1 and t2 gives the cycle time and its reciprocal is the frequency.

Example: a frequency of 10 Hz is required and would lead to periodic duration of 100 ms. This 100 ms can be freely allocated to t1 and t2, e.g. 50 ms:50 ms (isosceles triangle) or 99.9 ms:0.1 ms (right-angled triangle or sawtooth).

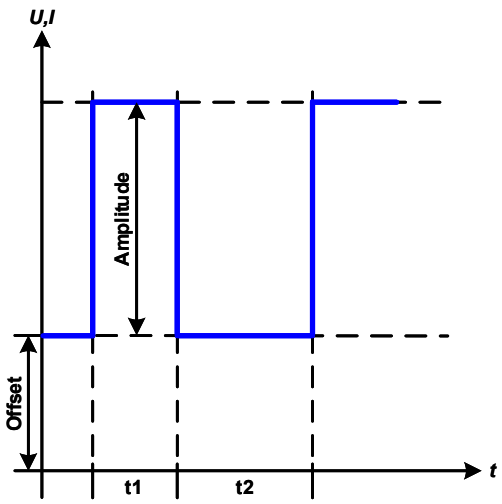
3.9.6 Rectangular function

The following parameters can be configured for a rectangular wave function:

Value	Range	Description
Ampl.	0...(Rated value - Offset)) of U or I	Ampl. = Amplitude of the signal to be generated
Offset	0...(Rated value - Ampl) of U or I	Offset, based on the foot of the rectangular wave
t1	0.01 ms...6000 s	Time (pulse width) of the upper level (amplitude)
t2	0.01 ms...6000 s	Time (pause width) of the lower level (offset)

When adjusting very short time value for t1 and t2 not every adjustable amplitude can be gained on the DC input. Rule of thumb: the smaller the time value, the lower the true amplitude.

Schematic diagram:



Application and result:

A rectangular or square wave signal for input current or input voltage is generated. The intervals t1 and t2 define how long the value of the amplitude (pulse) and how long the value of the offset (pause) are effective.

The offset shifts the signal on the Y axis.

Intervals t1 and t2 can be used to define a duty cycle. The sum of t1 and t2 gives the period and its reciprocal is the frequency.

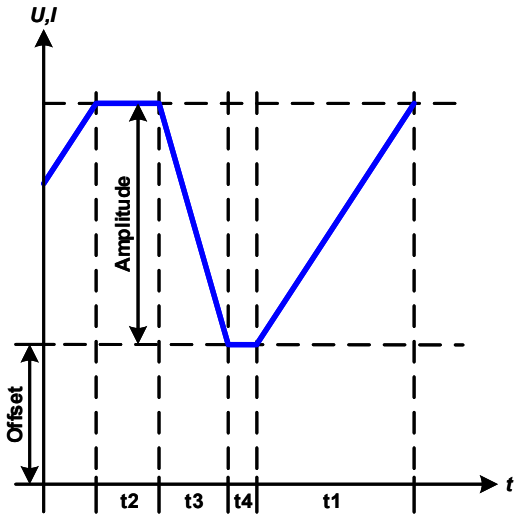
Example: a rectangular wave signal of 25 Hz and a duty cycle of 80% are required. The sum of t1 and t2, the period, is 1/25 Hz = 40 ms. For a duty cycle of 80% the pulse time (t1) is 40 ms*0.8 = 32 ms and the pause time (t2) is 8 ms

3.9.7 Trapezoidal function

The following parameters can be configured for a trapezoidal curve function:

Value	Range	Description
Ampl.	0...(Rated value - Offset)) of U or I	Ampl. = Amplitude of the signal to be generated
Offset	0...(Rated value - Ampl) of U or I	Offset, based on the foot of the trapezium
t1	0.01 ms...6000 s	Time for the negative slope of the trapezoidal wave signal
t2	0.01 ms...6000 s	Time for the top value of the trapezoidal wave signal
t3	0.01 ms...6000 s	Time for the negative slope of the trapezoidal wave signal
t4	0.01 ms...6000 s	Time for the base value (offset) of the trapezoidal wave signal

Schematic diagram:



Application and result:

Here a trapezoidal signal can be applied to a set value of U or I. The slopes of the trapezium can be different by setting different times for rise and fall.

The periodic duration and repeat frequency are the result of four time elements. With suitable settings the trapezium can be deformed to a triangular or rectangular wave. It has, therefore, universal use.

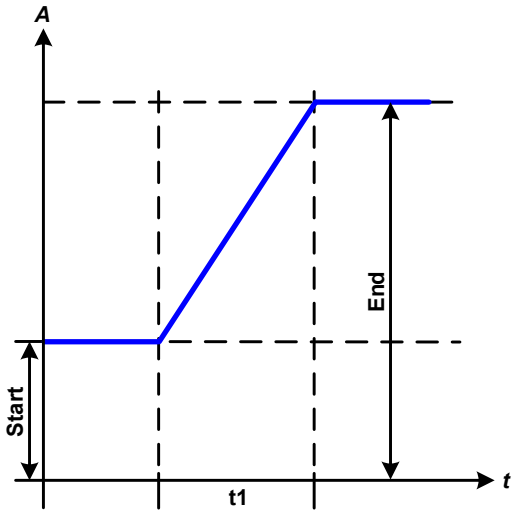
When adjusting very short time values for t1 not every adjustable amplitude can be gained on the DC input. Rule of thumb: the smaller the time value, the lower the true amplitude.

3.9.8 Ramp function

The following parameters can be configured for a ramp function.

Value	Range	Description
Start	0...Nominal value of U, I	Start level of the ramp
End	0...Nominal value of U, I	End level of the ramp,
t1	0.01 ms...36000 s	Time before ramp-up or ramp-down of the signal.

Schematic diagram:



Application and result:

This function generates a rising or falling ramp between start and end values over the time t1.

The function runs once and stops at the end value. To have a repeating ramp, function Trapezoid would have to be used instead (see *3.9.7*).

Important to consider is the static value of U or I which defines the static level before actually starting the ramp. It is recommended that this value is set equal to the value “Start”.

3.9.9 Battery test function

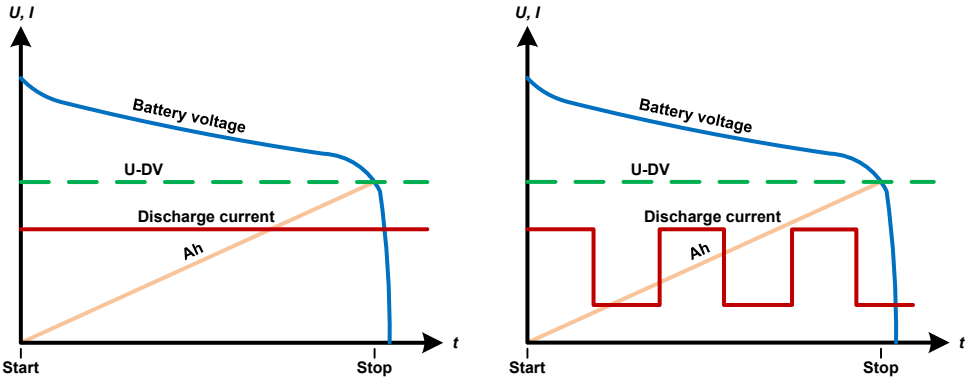
The purpose of the battery test function is to discharge various battery types in industrial product tests or laboratory applications. It is only available via access on the HMI, at least as setup and use are described below, but can also be achieved in remote control using the arbitrary function generator. The only disadvantage in remote control are the missing counters of battery capacity (Ah), energy (Wh) and time. But those can be calculated by custom remote control software when programming a time counter and regularly querying actual values from the device.

The function is usually applied on the DC input current and can either be selected and run in **Static** (**c**onstant current) or **Dynamic** (pulsed current) mode. In static mode, the settings for power or resistance can also let the device run the function in constant power (CP) or constant resistance (CR). Like in the normal operation of the load the set values determine what regulation mode (CC, CP, CR) is resulting on the DC input. If, for example, CP operation is projected, the set values of current should be set to maximum and resistance mode should be turned off (here: setting the R value to **OFF**), so that both don't interfere. For a projected CR operation it's similar. There current and power should be set to maximum.

For dynamic mode there is also a power setting, but it can't be used to run the dynamic battery test function in pulsed power mode or at least the result would not be as expected. It is recommended to adjust the power values always according to the test parameters, so it doesn't interfere with the pulsed current, i. e. dynamic mode.

When discharging with high currents, compared to the nominal battery capacity and in dynamic mode, it may happen that the battery voltage shortly drops below the threshold **Discharge voltage** (short: U_{DV}) and the test will unintentionally stop. Here it's recommended to adjust the threshold accordingly.

Graphical depiction of both battery test modes:



Static Dynamic

3.9.9.1 Parameters for static mode

The following parameters can be configured for the static battery test function.

Value	Range	Description
I	0...Nominal value of I	Maximum discharge current in Ampere
P	0...Nominal value of P	Maximum discharge power in Watt
R	R_{MIN}...R_{MAX}	Maximum discharge resistance in Ω (can be deactivated --> **OFF**)

3.9.9.2 Parameters for dynamic mode

The following parameters can be configured for the dynamic battery test function.

Value	Range	Description
I1	0...Nominal value of I	Upper resp. lower current setting for pulsed operation (the higher value of both is automatically used as upper level)
I2	0...Nominal value of I	
P	0...Nominal value of P	Maximum discharge power in Watt
t1	1 s ... 6000 s	t1 = Time for the upper level of the pulsed current (pulse)
t2	1 s ... 6000 s	t2 = Time for the lower level of the pulsed current (pause)

3.9.9.3 Other parameters

These parameters are available in both battery test modes, but the values are separately adjustable in each.

Parameter	Range	Description
Discharge voltage	0...Nominal value of U	Variable voltage threshold to make the test stop when reached (is connected to the battery voltage on the DC input of the load)
Discharge time	0...10 h	Maximum test time after which the test can stop automatically
Discharge capacity	0...99999 Ah	Maximum capacity to consume from the battery after which the test can stop automatically
Action	**NONE**, **SIGNAL**, **End of test**	Separately defines an action for parameters „Discharge time“ and „Discharge capacity“. It determines what shall happen with the test run once the adjusted values for those parameters are reached: **NONE** = No action, test will continue **SIGNAL** = Text “Time limit” will be displayed, test will continue **End of test** = The test will stop

3.9.9.4 Displayed values

During the test run, the display will show a set of values and status:

- Actual battery voltage on the DC input in V
- Actual discharge current in A
- Actual power in W
- Consumed battery capacity in Ah
- Consumed energy in Wh
- Elapsed time in HH:MM:SS,MS
- Regulation mode (CC, CP, CR)

3.9.9.5 Possible reasons for battery test stop

The battery test function run can be stopped by different reasons:

- Manual stop on the HMI with buttons 

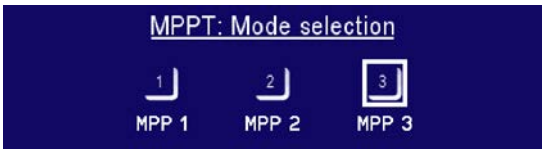
or 

- After the max. test time has been reached and if action **End of test** was set for it
- After the max. battery capacity to consume has been reached and if action **End of test** was set for it
- Any device alarm which would also switch off the DC input, like OT
- Passing the discharge voltage threshold, which is equivalent to any voltage drop on the DC input caused by whatever reason

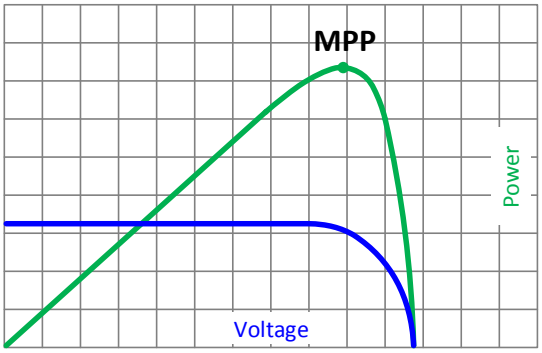
After an automatic stop, caused by any of the listed reasons and removing the cause of an alarm, the test can be continued. Reset of counted values is done by leaving the function generator screen.

3.9.10 MPP tracking function

MPP stands for the maximum power point (see principle view to the right) on the power curve of solar panels. Solar inverters, when connected to such panels, constantly track this MPP once it has been found.



The electronic load simulates this behaviour by a function. It can be used to test even huge solar panels without having to connect a usually big solar inverter device which also requires to have a load connected to its AC output. Furthermore, all MPP tracking related parameters of the load can be adjusted and it so is much more flexible than an inverter with its limited DC input range.



For evaluation and analysis purposes, the load can also record measured data, i. e. DC input values such as actual voltage, current or power, to USB stick or provide them for reading via digital interface.

The MPP tracking function, as it's manually usable on the HMI, offers three modes. A fourth mode is available for remote control via any of the optionally available digital interfaces (USB, Ethernet).

3.9.10.1 Mode MPP1

This mode is also called "find MPP". It is the simplest option to have the electronic load find the MPP of a connected solar panel. It requires to set only three parameters. Value U_{OC} is necessary, because it helps to find the MPP quicker as if the load would start at 0 V or maximum voltage. Actually, it would start at a voltage level slightly above U_{OC}.

I_{SC} is used as an upper limit for the current, so the load would not try to draw more current than the panel is specified for.

Following parameters can be configured for tracking mode **MPP1**:

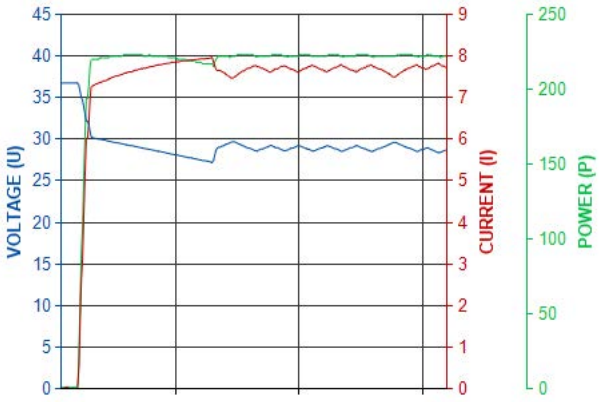
Value	Range	Description
U_{OC}	0...Nominal value of U	Voltage of the solar panel when unloaded, taken from the panel specs
I_{SC}	0...Nominal value of I	Short-circuit current, max. specified current of the solar panel
Δt	5...60000 ms	Time between two tracking attempts when finding the MPP

Application and result:

After the three parameters have been set, the function can be started. As soon as the MPP has been found, the function will stop and switch off the DC input. The acquired MPP values of voltage (U_{MPP}), current (I_{MPP}) and power (P_{MPP}) are then shown in the display.
The time of a function run depends on the parameter Δt. Even with the minimum setting of 5 ms one run take already a few seconds.

3.9.10.2 Mode MPP2

This mode tracks the MPP, so it's closest to the operation of a solar inverter. Once the MPP is found, the function won't stop, but try to track the MPP permanently. Due to the nature of solar panels this can only be done below the level of the MPP. As soon as this point is reached, the voltage starts to sink further and so does the actual power. The additional parameter **ΔP** defines how much the power may sink before the direction is reversed and the voltage starts to rise again until the load reaches the MPP. The result is a zigzag shaped curve of both, voltage and current.



A typical curve display is shown in the picture to the right. For the example, the **ΔP** was set to a quite small value, so the power curve looks almost linear. With a small **ΔP** the load would always track close to the MPP.

Following parameters can be configured for tracking mode **MPP2**:

Value	Range	Description
U_{OC}	0...Nominal value of U	Voltage of the solar panel when unloaded, taken from the panel specs
I_{SC}	0...Nominal value of I	Short-circuit current, max. specified current of the solar panel
Δt	5...60000 ms	Interval for measuring U and I during the process of finding the MPP
ΔP	0 W...P_{Nom}	Tracking/regulation tolerance below the MPP

3.9.10.3 Mode MPP3

Also called “fast track”, this mode is very similar to mode MPP2, but without the initial step which is used to find the actual MPP, because mode MPP3 would directly jump to the power point defined by user input (U_{MPP}, P_{MPP}). In case the MPP values of the equipment under test are known, this can save a lot of time in repetitive tests. The rest of the function run is the same as with MPP2 mode. During and after the function, the least acquired MPP values of voltage (U_{MPP}), current (I_{MPP}) and power (P_{MPP}) are shown in the display.

Following parameters can be configured for tracking mode **MPP3**:

Value	Range	Description
U_{OC}	0...Nominal value of U	Voltage of the solar panel when unloaded, taken from the panel specs
I_{SC}	0...Nominal value of I	Short-circuit current, max. specified current of the solar panel
U_{MPP}	0...Nominal value of U	Voltage in the MPP
P_{MPP}	0...Nominal value of P	Power in the MPP
Δt	5...60000 ms	Interval for measuring U and I during the process of finding the MPP
ΔP	0 W...P_{Nom}	Tracking/regulation tolerance below the MPP

3.9.10.4 Mode MPP4

This mode is different, because it does not track automatically. It rather offers the choice to define an user curve by setting up to 100 points of voltage values, then track this curve, measure current and power and return the results in up to 100 sets of acquired data.

Start and end point can be adjusted arbitrarily, Δt defines the time between two points and the function run can be repeated up to 255 times. Once the function stops at the end or by manual interrupt, the DC input is switched off and the measured data is made available.

Configuration, control and analysis are all done using any of the optionally available, digital interfaces (USB, Ethernet). This mode is supported by ModBus RTU and SCPI protocol, as well as by the software EA Power Control, which is included with the devices or interface option on USB stick.

3.9.11 Remote control of the function generator

The function generator can be remotely controlled via any of the optionally available, digital interfaces (USB, Ethernet), but configuration and control of the functions with individual commands is different from manual operation. The external documentation “Programming Guide ModBus & SCPI” on USB stick, which is included with the interface option, explains the approach. In general the following items apply:

- The function generator isn’t controllable via the analog interface

3.10 Other applications

3.10.1 Series connection

Series connection isn't a permissible operating method for electronic loads and must not be installed or operated under any circumstances!

3.10.2 Parallel operation

Multiple devices of same kind and ideally same model can be connected in parallel in order to create a system with higher total current and hence higher power. This can be achieved by connecting all units to the DC source in parallel, so the total current can spread across all devices. There is no support for a balancing between the individual units, like in form of a master-slave system. All loads would have to be controlled and set up separately. However, it's possible to have a parallel control by the signals on the analog interface, as this one is galvanically isolated from the rest of the device. There are few general points to consider and adhere:

- Always make parallel connections only with device of same voltage, current and power rating, but at least with those of the same voltage rating
- Never connect the ground signal of any analog interface with the negative DC input, because it will void the galvanic isolation. This rule is especially important when going to connect any DC input pole to ground (PE) or to shift its potential.
- Never connect DC input cables from load device to load device, but instead from every load device directly to the source, else the total current will exceed the current rating of the DC input clamp

4. Service and maintenance

4.1 Maintenance / cleaning

The device needs no maintenance. Cleaning may be needed for the internal fans, the frequency of cleanse is depending on the ambient conditions. The fans serve to cool the components which are heated by the inherent high dissipation of energy. Heavily dirt filled fans can lead to insufficient airflow and therefore the DC input would switch off too early due to overheating or possibly lead to defects.

Cleaning the internal fans can be performed with a vacuum cleaner or similar. For this the device needs to be opened.

4.2 Fault finding / diagnosis / repair

If the equipment suddenly performs in an unexpected way, which indicates a fault, or it has an obvious defect, this can't and must not be repaired by the user. Contact the supplier in case of suspicion and elicit the steps to be taken.

It will then usually be necessary to return the device to Elektro-Automatik (with or without warranty). If a return for checking or repair is to be carried out, ensure that:

- the supplier has been contacted and it's clarified how and where the equipment should be sent.
- the device is in fully assembled state and in suitable transport packaging, ideally the original packaging.
- a fault description in as much detail as possible is attached.
- if shipping destination is abroad, the necessary customs papers are attached.

4.2.1 Replacing a defect mains fuse

The device is protected by a fusible which is inside a fuse holder on the rear of the device. The fuse rating is printed next to the fuse holder. Replace the fuse only with one of same size and rating.

Firmware updates should only be installed when they can eliminate existing bugs in the firmware in the device or contain new features.

The firmware of the control panel (HMI), of the communication unit (KE) and the digital controller (DR), if necessary, is updated via the rear side USB port. For this the software EA Power Control is needed which is included with the device or available as download from our website together with the firmware update, or upon request.

However, be advised not to install updates promptly. Every update includes the risk of an inoperable device or system. We recommend to install updates only if...

- an imminent problem with your device can directly be solved, especially if we suggested to install an update during a support case
- a new feature has been added which you definitely want to use. In this case, the full responsibility is transferred to you.

Following also applies in connection with firmware updates:

- Simple changes in firmwares can have crucial effects on the application the devices are use in. We thus recommend to study the list of changes in the firmware history very thoroughly.
- Newly implemented features may require an updated documentation (user manual and/or programming guide, as well as LabVIEW VIs), which is often delivered only later, sometimes significantly later

5. Contact and support

5.1 Repairs

Repairs, if not otherwise arranged between supplier and customer, will be carried out by EA Elektro-Automatik. For this the equipment must generally be returned to the manufacturer. No RMA number is needed. It is sufficient to package the equipment adequately and send it, together with a detailed description of the fault and, if still under guarantee, a copy of the invoice, to the following address.

5.2 Contact options

Questions or problems with operation of the device, use of optional components, with the documentation or software, can be addressed to technical support either by telephone or e-Mail.

Headquarter	e-Mail	Telephone
EA Elektro-Automatik Helmholtzstr. 31-37 41747 Viersen Germany	Technical support: support@elektroautomatik.de All other topics: ea1974@elektroautomatik.de	Switchboard: +49 2162 / 37850 Support: +49 2162 / 378566

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